Port of San Francisco Economic and Air Quality Impact Analysis of the Tunnel Improvement Project

Port of San Francisco
City and County of
San Francisco

April 1993

EPS

Economic & Planning Systems

In Association with:

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EXECUTIVE SUMMARY

INTRODUCTION

- Changing trends in containerized cargo trade have resulted in increased utilization of high cube containers. In order for San Francisco to handle the increasing volumes of cargo bound for West Coast ports, improvements to tunnel height clearances need to be made so that double-stacked, high cube intermodal rail containers can be accommodated.

- The purpose of this report is to analyze the economic and air quality impacts of constructing tunnel improvements to two tunnels along the Southern Pacific Main Lines into and out of San Francisco.

- Three alternative scenarios have been analyzed. Alternatives 1 and 2A have been compared in terms of the economic impacts generated; Alternatives 2A and 2B have been compared in terms of the air quality impacts generated. Descriptions of the alternative scenarios follow:

  Alternative 1: the tunnel improvements would not be constructed. As a result, the Port would experience a significant drop in containerized cargo volumes because container shipping lines would not be able to quickly and efficiently transport their inland-bound cargo through the Port.

  Alternative 2A: the tunnel improvements would be constructed, thereby removing the tunnel height constraints and allowing additional containerized cargo to be transported by rail. It is anticipated that the increase in rail activity would result in reduced drayage by truck and therefore improved air quality in the region.

  Alternative 2B: the tunnel improvements would be not constructed. For the purpose of the air quality analysis, forecasts of cargo volumes have been assumed to be the same as under Alternative 2A. Because the cargo would be transported almost exclusively by truck in this scenario, a decrease in the air quality in the region is expected compared to Alternative 2A.

CARGO THROUGHPUT CAPACITY AND MARKET DEMAND ANALYSIS

- Container cargo volumes are estimated for each alternative based on Port facility and/or capacity constraints, growth forecasts of West Coast containerized cargo trade, and the competitive position of the Port of San Francisco (the Port).

CAPACITY CONSTRAINTS

- Potential cargo throughput capacities have been estimated for the Port's container terminals, the intermodal container transfer facility (ICTF), and the railroad tunnels. The optimum capacity of each component is estimated as follows: container terminals -- 300,000 TEUs per year; ICTF -- 112,500 TEUs per year; and railroad tunnels -- 172,000 TEUs per year.

- At a maximum, 25 percent of total cargo volumes will be transported through the ICTF and railroad tunnels. Therefore, if cargo volumes at the container terminals reach capacity (300,000 TEUs), they will not be constrained by the capacities of the ICTF and the railroad tunnels.

GROWTH FORECASTS

- An evaluation and synthesis of previous market analysis conducted by Vickerman-Zachary-Miller and other marine planning firms indicates that West Coast port cargo trade is expected to grow by five percent per year through the Year 2000.

- It is anticipated that future cargo growth at the San Francisco Port will be a combination of growth in existing West Coast port cargo operations and an increased capture of future growth in discretionary cargo. Discretionary cargo is defined as cargo that is not bound for local destinations and can be moved from one Port to another at the discretion of the shipping line. Future growth in West Coast discretionary cargo is expected to equal 2.3 million TEUs in the Year 2000.

- Currently, container cargo volumes at the Port or San Francisco are equal to 114,000 TEUs per year (twenty foot equivalent units). In order for the Port to achieve cargo volumes equal to the optimum capacity of Port container shipping facilities (300,000 TEUs), existing cargo volumes at the Port would need to increase at five percent per year, (consistent with West Coast port cargo growth projections) and the Port would need to capture 5.6 percent (130,000 TEUs) of the anticipated growth in West Coast discretionary cargo.

- With the tunnel improvements, the San Francisco Port would be well-positioned to achieve this amount of growth given its competitive advantages, which include an on-dock intermodal yard, the availability of land, natural deep water, good transportation links, and a very strong regional market.

- Without the tunnel improvements, however, it is unlikely that cargo transport services could continue to be provided to container shipping lines at competitive rates. As a result, the market demand for the Port terminals would be significantly reduced. Therefore, it is unlikely that existing cargo volumes at the Port would increase at the rates forecasted for West Coast ports. In fact, it is very possible that the Port could experience a decrease in cargo volumes over time.

ECONOMIC IMPACTS

- The direct, indirect and induced economic impacts generated in Alternatives 1 and 2A have been analyzed and compared. Direct impacts are those which are directly associated with Port-related operations. Indirect impacts are generated as a result of Port-related businesses purchasing labor, supplies and materials from other firms or from independent contractors. Induced impacts are generated when persons employed directly by the Port spend their disposable income on goods and services.

EMPLOYMENT

- Total direct and indirect employment generated from containerized cargo handling, Port users and construction of the tunnel project is equal to 1,896 employees in Alternative 1 and 7,756 employees in Alternative 2A, resulting in an incremental gain of **5,859 full-time employees per year** if the tunnel improvements are constructed (see **Table ES-1 and Figure ES-1**).

REVENUES

- Total direct and indirect annual revenues generated with and without the tunnel improvements are summarized in **Table ES-1 and Figure ES-2**. Alternative 1, which assumes no tunnel improvements are made, generates $110 million in annual revenues compared to $453 million in Alternative 2A. This results in an incremental difference of **$343 million in annual revenues**.

PAYROLL

- Total direct and indirect payroll revenues generated are equal to $54 million in Alternative 1 and $218 million in Alternative 2A, equating to an incremental gain of **$165 million in annual payroll revenues** if the tunnel improvements are made (**see Table ES-1 and Figure ES-3**).

TAX REVENUES

- Local San Francisco tax revenues that generate a significant amount of revenues include payroll expense tax, business tax, and local sales tax, and are summarized in **Table ES-1 and Figure ES-4**). Total annual tax revenues equal $444,000 in Alternative 1 and $1.8 million in Alternative 2A, resulting in an incremental gain of **$1.4 million in annual local tax revenues**, if the tunnel improvements are made.

Table ES-1
Summary of Annual Economic Impacts
Tunnel Economic Impact Analysis [1]

Economic Impact	Alternative 1	Alternative 2A	Incremental Change
Employment			
Direct [2]	1,072	4,389	3,317
Indirect and Induced [3]	824	3,367	2,543
Total	1,896	7,756	5,859
Revenues ($000)			
Direct	$66,843	$276,239	$209,396
Indirect and Induced	43,448	177,136	133,688
Total	$110,291	$453,375	$343,084
Payroll ($000)			
Direct	$33,353	$135,578	$102,225
Indirect and Induced	20,344	82,807	62,463
Total	$53,698	$218,385	$164,687
Local Tax Revenues ($000)	$444	$1,828	$1,383

---

[1] Alternative 1 assumes that the tunnel improvements are not made. As a result, the Port experiences a significant drop in containerized cargo volumes because container shipping lines are not able to quickly and efficiently transport their inland-bound cargo through the Port.
Alternative 2A assumes that the tunnel height constraints are removed, thereby allowing additional containerized cargo to be transported by rail.

[2] Direct economic impacts are those associated directly with Port operations. This study focuses on the direct economic impacts generated as a result of container shipping activities, excluding break bulk and automotive shipping.

[3] Indirect impacts are generated as a result of Port-related businesses purchasing labor, supplies and materials from other firms. Persons directly employed by Port-related businesses generate induced impacts when they spend their disposable income on goods and services such as food, housing, transportation, etc.

Source: Vickerman-Zachary-Miller, Port of San Francisco, Economic and Planning Systems, Inc.

Figure ES-1
Estimated Total Direct and Indirect Employment
(in FTEs)
Tunnel Economic Impact Analysis

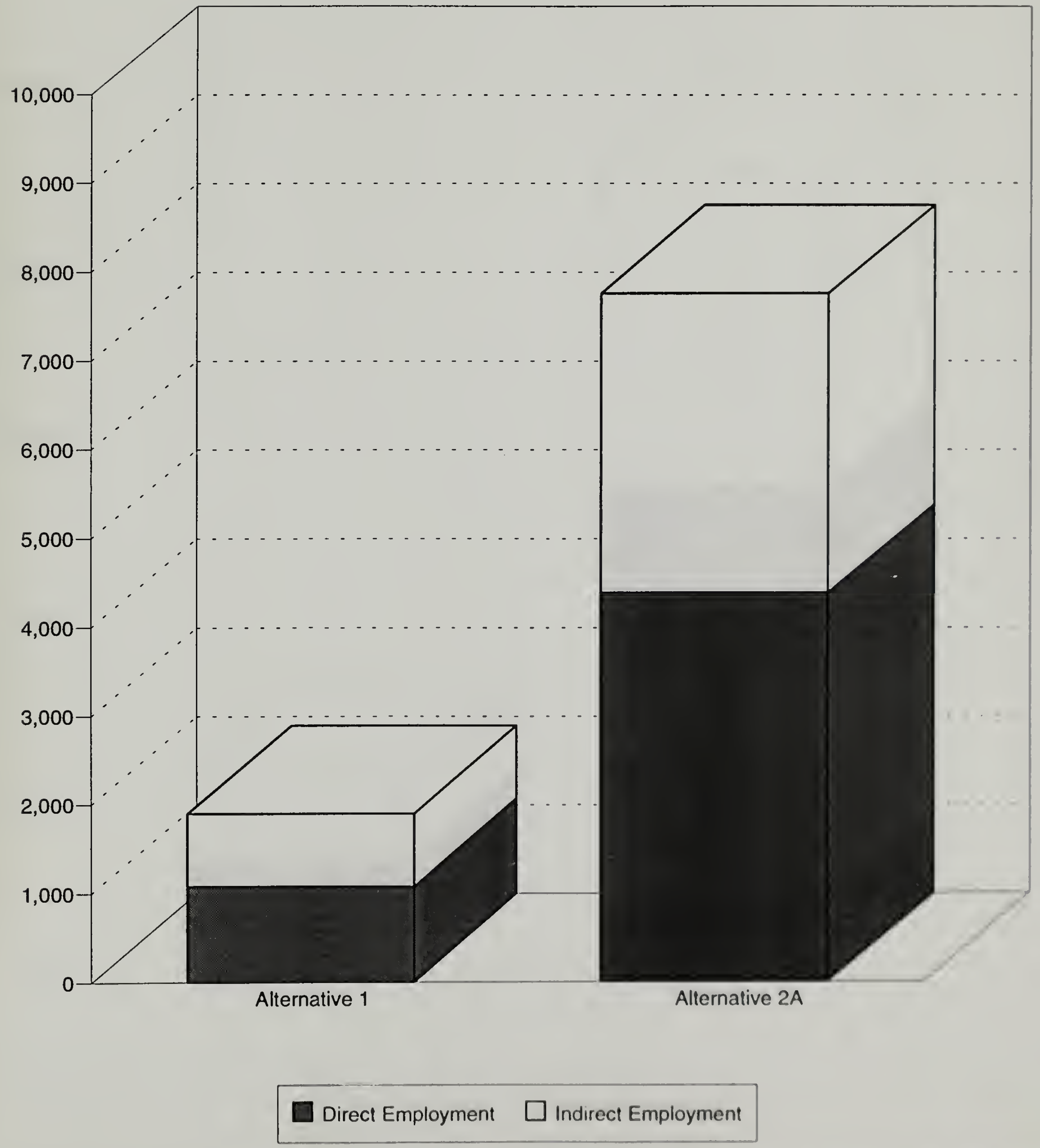


Figure ES-2
Estimated Total Direct and Indirect Revenues
(in millions)
Tunnel Economic Impact Analysis

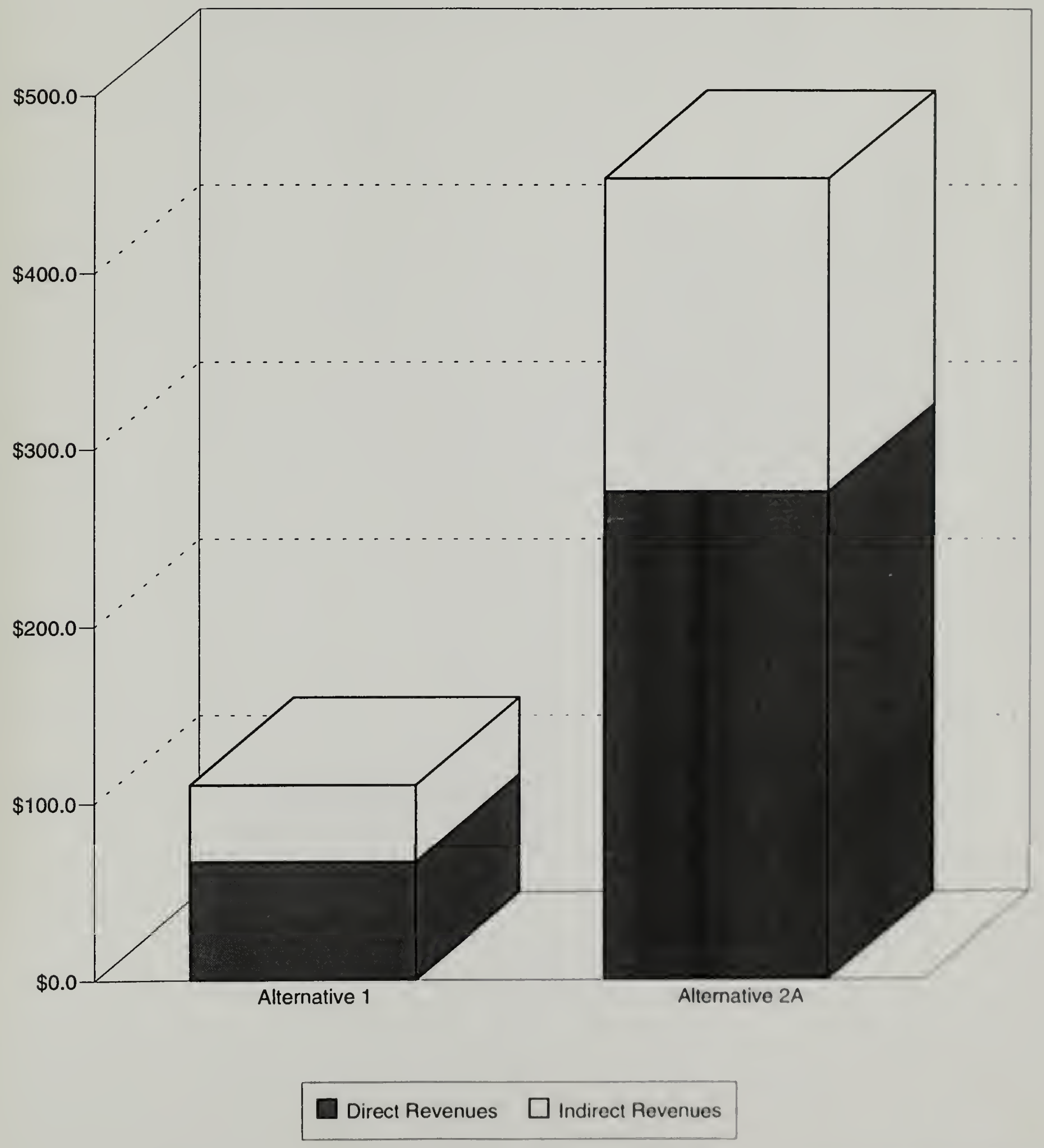


Figure ES-3
Estimated Total Direct and Indirect Payroll
(in millions)
Tunnel Economic Impact Analysis

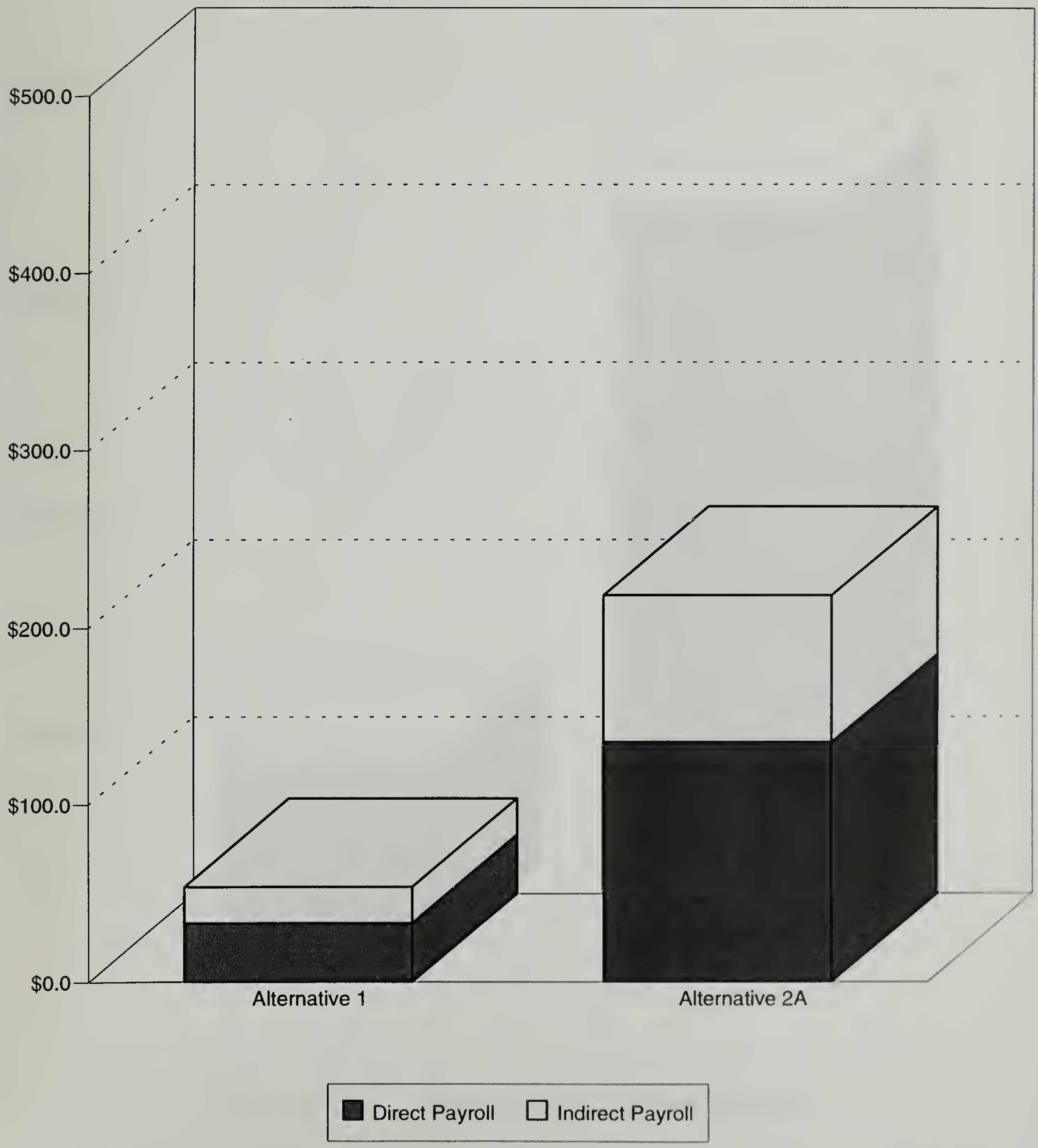
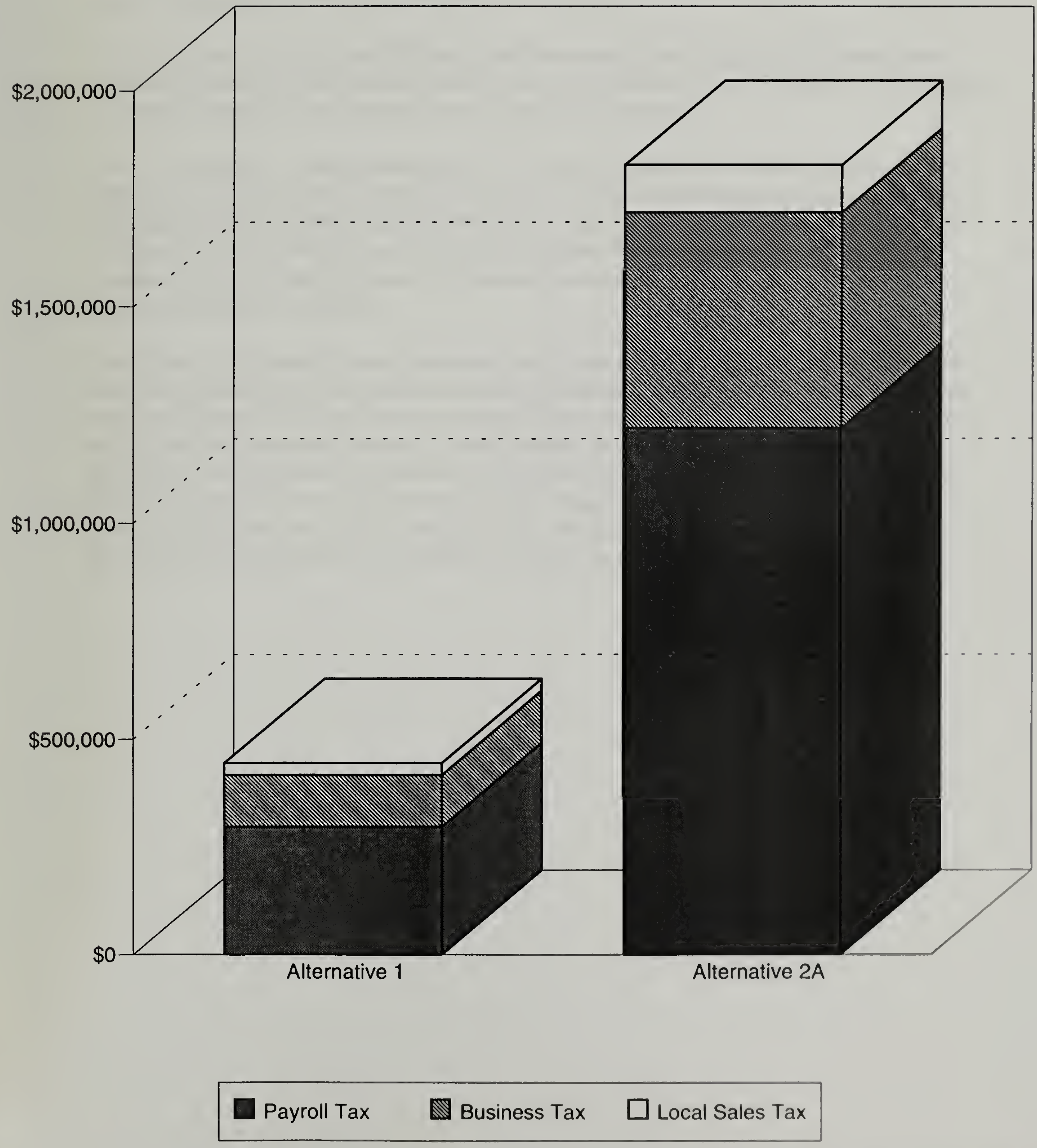


Figure ES-4
Estimated Total Local Tax Revenues
Tunnel Economic Impact Analysis



AIR QUALITY IMPACTS

- With the tunnel project, there would be an overall decrease in pollutants by 41.21 kilograms of nitrogen oxides, 12.63 kilograms of hydrocarbons, 37.52 kilograms of carbon monoxide, and 0.77 kilograms of particulates (refer to **Table ES-2**). Both the truck and the switch locomotives generate high levels of nitrogen oxides which are typically associated with diesel engines.

- With the tunnel project, over 340 daily (88,400 annual) truck trips would be replaced with the operation of the switch trains in the yard. Overall, this will lead to a net benefit in regional emissions, and improved air quality in the basin.

- Indirect regional air quality benefits would also be derived from reduced freeway congestion. In particular, with the tunnel project, the congestion on the Bay Bridge and on Interstates 80 and 880 would be reduced, as this would be the major freeway truck routes to the Ports of Richmond and Oakland from the Port of San Francisco. There would also be a further decrease in emissions associated with the operation of trucks during congested conditions.

- In addition to air quality considerations, each alternative scenario would also affect fuel and energy efficiency. Intermodal facilities primarily handle double-stacked container cars, stacked in a two-high, five-unit long configuration. In comparison to conventional equipment, a double-stacked cargo configuration saves fuel, utilizes capacity more efficiently, and requires less maintenance with more efficient handling of cargo. With the tunnel project, an estimated 25 percent of cargo would be transported by rail as compared to 5 percent under Alternative 2B. The increased use of rail under Alternative 2A would result in greater car capacity with improved energy and fuel efficiency.

Table ES-2
Estimated Total Air Quality Emissions
Tunnel Air Quality Impact Analysis

	Kilograms Per Day		
Pollutant	Alternative 2A	Alternative 2B	Difference
Sulpher Dioxide (SO_2)	0.99	negligible	0.99
Nitrogen Oxides (NO_x)	527.81	569.02	41.21
Hydrocarbons (HC)	109.33	121.96	12.63
Carbon Monoxide (CO)	336.46	373.98	37.52
Particulates (PM_{10})	10.28	11.05	0.77

Source: David Evans and Associates, Inc., 1993.

I. INTRODUCTION

BACKGROUND AND PURPOSE

In recent years, there have been several changes and innovations in maritime trade which have had a significant effect on West Coast ports. As countries in the Far East, Southeast Asia, and South Asia become industrialized, the amount of transpacific trade has substantially increased. The containerization of cargo has led to increased use of intermodal transportation in the U.S., where containerized cargo from Pacific Rim countries is shipped through West Coast ports and then transferred onto trains for transport to the East Coast. The emergence of double-stacked container trains as an efficient and economical means of intermodal rail transport increases the importance of West Coast ports' role in transporting goods to and from the East Coast.

These trends in maritime trade have resulted in substantial growth in the volume of containerized cargo arriving at West Coast ports. In order for the Port of San Francisco to accommodate a portion of that growth, it must be able to provide double-stacked intermodal rail service directly from Port terminals. Currently, double-stacked rail cars from the Port terminals must be transported through two rail tunnels with limited height clearances. Under current conditions, the tunnels are only able to accommodate two 8 foot 6 inch high containers, and not without potential safety clearance problems. A large component of containerized cargo growth expected at West Coast ports will be in the form of "high cube" containers, which are typically 9 feet 6 inches high.

Therefore, improvements to the tunnels are required in order to facilitate the intermodal transport of containerized cargo from the Port to other parts of the U.S. Without these tunnel improvements, the San Francisco Port may not only experience a decrease in competitiveness for its share of future cargo growth, but may also lose existing business from shipping lines currently calling at the Port.

The purpose of this report is to analyze the economic impacts of making improvements to two railroad tunnels along the Southern Pacific Main Lines into and out of San Francisco. Alternative scenarios, with and without the tunnel improvements, are compared in terms of the amount of economic benefits generated. The economic impacts quantified in this report include employment, gross revenues, payroll, and local tax revenues directly attributable to or generated by containerized cargo operations at the Port.

In addition, regional air quality implications are examined for each alternative scenario. Improvements to the railroad tunnels will result in net regional air quality benefits. This is due, in large part, to the decreased number of regional truck trips that will no longer be required if direct rail access is provided from the Port of San Francisco.

DESCRIPTION OF THE TUNNEL PROJECT

The Tunnel Improvement Project involves Tunnels #3 and #4 along the Southern Pacific Main Lines. The tracks are currently used by commuter and freight rail traffic by Amtrak (as part of a contract with the Joint Powers Board regarding the Caltrain commuter train) and Southern Pacific, respectively. The major components of the proposed project include:

1. Installation of a "gauntlet track" between the existing two sets of tracks, beneath the highest part of the tunnel arch. This will allow railroad cars to carry high cube double-stacked containers through the tunnel.

2. Extension of a centralized traffic control system (CTC) from Fourth and Townsend Streets to the San Mateo County line; this will include the installation of electric "crossover" switches which will allow trains to switch tracks, thereby facilitating the efficient movement of commuter and rail trains through the tunnel.

3. Construction of the Bayshore Support Yard, where unit trains of containerized freight will be assembled.

4. Improvements to the Quint Street lead, which connects the main line to the Intermodal Container Transfer Facility (ICTF).

5. Expansion of clearance at the Paul Avenue overpass.

The total cost of the tunnel improvements is currently estimated at $11 million. Similar tunnel improvement projects have been undertaken by the Southern Pacific Railroad throughout the U.S. in order to improve tunnel clearances, thereby allowing intermodal transport via double-stacked rail cars.

METHODOLOGY

This report analyzes and compares the economic and air quality impacts generated from the transport of containerized cargo through the Port of San Francisco under three alternative scenarios. **Alternative 1** assumes that the tunnel improvements are not made. Under this alternative, the impact on San Francisco cargo volumes, given containerized shipping trends, is estimated. Cargo volumes in the second scenario (**Alternative 2A**) are based on market demand for the Port's facilities given West Coast cargo growth forecasts, the Port's competitive position in the marketplace, and the assumption that the height constraints of the tunnels are removed.

Alternatives 1 and 2A have been developed for the purposes of quantifying plausible, market-based cargo forecasts with and without the tunnel improvements. These two alternatives are analyzed and compared in order to quantify the incremental economic impacts of the tunnel improvement project.

In **Alternative 2B**, it is assumed that the cargo volumes outlined in the market demand scenario are achieved, using truck drayage instead of intermodal rail transport. While this is physically possible based on the operating capacity of the Port's facilities, it may be cost-prohibitive, due to the inefficiencies and expense of drayage compared to double-stacked rail intermodal transport. Alternative 2A and Alternative 2B provide a comparable basis for measuring and analyzing air quality impacts under similar, market-based scenarios.

The scenarios are described in more detail below:

Alternative #1: Loss of Trade

Under this alternative, the tunnel improvements are not made. As a result, the Port experiences a significant drop in containerized cargo volumes because container shipping lines are not able to quickly and efficiently transport their inland-bound cargo through the Port. This reduced level of activity may involve the loss of one or more transpacific container shipping lines.

Alternative #2A: Market Demand (with Rail)

Under this alternative, the tunnel improvements are made, thereby removing the tunnel height constraints and allowing additional containerized cargo to be transported by rail. It is anticipated that the increase in rail activity will result in reduced drayage and therefore improved air quality in the region, relative to a similar level of activity without double-stacked rail capability.

The estimated volume of containerized cargo coming through the Port is based on forecasts of market demand, given the capacity of the Port's terminals and intermodal container transfer facility (ICTF). With the exception of the tunnel improvements and container terminal-related projects that are currently underway, no other capital improvements are assumed. The market forecast has been prepared by Vickerman-Zachary-Miller and is outlined in detail in **Chapter II**.

Alternative #2B: Market Demand (with Drayage)

Under this alternative, the tunnel improvements are not made, but for the purposes of the air quality analysis, forecasts of cargo volumes based on the market demand factors are assumed to be achieved via drayage to the Richmond intermodal facility or to Oakland.

For each alternative, **direct economic impacts**, including employment, payroll, gross revenues and local tax revenues are quantified. Direct economic impacts are those associated directly with Port-related operations. Because the tunnel improvements will directly affect the containerized cargo trade, this study focuses on the economic impacts generated as a result of container shipping activities, excluding break bulk and automotive shipping.

In addition to direct impacts, indirect and induced impacts are quantified by utilizing economic multipliers. **Indirect impacts** are generated as a result of Port-related businesses purchasing labor, supplies and materials from other firms or from independent contractors. Persons directly employed by Port-related businesses generate **induced impacts** when they spend their disposable income on goods and services such as food, housing, transportation, etc.

Economic & Planning Systems (EPS) and the consulting team have relied on information, economic data and economic multipliers from the "Port of San Francisco Economic Impact Report", prepared for the Port of San Francisco in September, 1988 by Trade Information Planning Systems. This information has been supplemented by interviews with stevedoring companies regarding container terminal and intermodal facility employment, with Port officials regarding facility constraints and cargo growth projections, and with city officials regarding the rates and collection procedures for local taxes. The consultant team has also evaluated and synthesized, where appropriate, previous market analysis conducted by Vickerman-Zachary-Miller (VZM) and other marine planning firms.

ORGANIZATION OF REPORT

This report is organized into an Executive Summary and four chapters. The **Executive Summary** highlights the results of analysis results. **Chapter I** summarizes the background and purpose of the report, outlines the alternative scenarios and discusses the report's methodology and assumptions. **Chapter II** outlines the estimated cargo volumes under each alternative, based on growth forecasts of West Coast containerized cargo trade, Port facility and/or capacity constraints, and the competitive position of the San Francisco Port. **Chapter III** analyzes and compares the economic impacts generated from containerized cargo shipping and related Port businesses under the "no tunnel" and "tunnel" alternatives. **Chapter IV** analyzes and compares the air quality impacts for Alternatives 2A and 2B, based on vehicle miles traveled (by truck or by train), the origin and destination of trips, and the amount and types of emissions generated.

II. CARGO THROUGHPUT CAPACITY AND MARKET DEMAND ANALYSIS

METHODOLOGY

The purpose of this chapter is to estimate cargo volumes under each alternative, based on port facility and/or capacity constraints, growth forecasts of West Coast containerized cargo trade, and the competitive position of the San Francisco Port. The cargo forecasts will be utilized to estimate and compare the economic impacts under Alternatives 1 and 2A, and used in conjunction with estimates of transportation mode splits to determine and compare the air quality impacts of Alternatives 2A and 2B.

In order to define the cargo economic and air quality impacts of the three proposed alternatives, the maximum cargo throughput was estimated and the limiting components of the Port facilities were identified. The potential containerized cargo growth for the Port was then examined in order to determine the likely portion of maximum throughput that could be marketable under the three alternative scenarios. Transportation mode splits were then estimated for each alternative based on the type of cargo (e.g. local or discretionary) and the destinations of cargo (e.g. local or non-local).

CARGO THROUGHPUT CAPACITY

Containerized cargo terminal throughput capacity depends upon the context in which it is measured. From the viewpoint of the cargo crane operator, all containers are handled the same, whether they are 20-foot or 40-foot, loaded or empty. In this context, they are referred to as units or lifts. Shipping companies, however, can only charge for loaded containers, and the size of the container makes a great deal of difference to them.

The most commonly used measure of containerized cargo is the 20-foot equivalent unit (TEU). This is a measure of the **static** capacity equal to one 20-foot container or one-half of a 40-foot container.

On average, 15 tons of cargo will go into one 40-foot container, or two 20-foot containers (TEUs). Since the same terminal resources are required to handle either size, one **Unit** of throughput can either be a 40-foot container or a 20-foot container. Therefore, the **Unit** is a measure of the **operational** capacity of a terminal handling method.

An average queue of ten trucks at the Port of San Francisco could have six 20-foot containers (one TEU apiece) and four 40-foot containers (two TEUs apiece). Therefore, (6 trucks X 1 TEU + 4 trucks X 2 TEUs)/10 total Units = **1.4 TEU per Unit.**

PORT CONTAINER TERMINAL CAPACITY

A computerized model was used to evaluate the marine cargo throughput capacity of the Port of San Francisco container terminals. This model is a spreadsheet-based program, designed to run on the standard business microcomputer platform. The distinguishing features of this model are the look-up tables of actual terminal survey data and the "what-if" file which allows the user to explore possible terminal operating scenarios.

There are six measurable components of a marine terminal affecting cargo throughput which are represented in the model:

- Vessel and berth activities
- Ship-to-apron transfer
- Apron-to-storage transfer
- Storage yard capacity
- Intermodal transfer
- Gate processing

Of these, the intermodal transfer component was modeled separately. The "what-if" data entry was based on a series of terminal questionnaires which were answered by the stevedoring firms at the container terminals.

Once a reasonably accurate model of the existing terminals was generated, the terminal components were balanced with each other to create a model of the Maximum Practical Capacity (MPC) under current conditions. Since the MPC measures the cargo capacity of a terminal with each component operating in an optimum mode, it is seldom achieved in actual practice. A more reasonable (and economically achievable) measure of capacity is at 75 percent of MPC.

The terminal model results are presented in **Table II-1** and are summarized as follows:

- Pier 80 MPC = 154,000 TEUs per year
- Pier 94-96 MPC = 246,000 TEUs per year
- Total Port MPC = 400,000 TEUs per year

INTERMODAL CONTAINER TRANSFER FACILITY CAPACITY

The current, on-dock, intermodal container transfer facility (ICTF) was analyzed using a model similar to the terminal model. This model was also based on the existing conditions at the Port and was then balanced to arrive at the MPC. Since it is an on-dock facility, it was assumed that container storage takes place at the adjacent terminal.

Table II-1
Port of San Francisco Container Throughput Capacity Model Terminal Operations

SUMMARY CAPABILITY ESTIMATES (TEU)

Containerized Cargo Model Throughput Capability (TEU per Year)	**PIER 94-96**	**PIER 80**
Component 1: Berth and Apron Activities	260,904	154,610
Component 2: Ship To Apron Transfer	356,335	211,162
Component 3: Apron To Storage Transfer	376,132	197,084
Component 4: Storage	246,780	254,179
Component 5: Intermodal Transfer	***************	***************
Component 6: Gate Processing	257,353	194,298
Maximum Practical Throughput Capacity Est.	246,780	154,610
Total Terminal Acres	76	69
Throughput Capability per Terminal Acre	3,247	2,241
Total Storage Acres	40	25
Throughput Capability per Storage Acre	6,169	6,184
Component Summary Table of Limiting Factors	**PIER 94-96**	**PIER 80**
Component 1: Berth and Apron Activities	....	Limiting Component
Component 2: Ship To Apron Transfer	....	....
Component 3: Apron To Storage Transfer	....	....
Component 4: Storage	Limiting Component	....
Component 5: Intermodal Transfer	....	....
Component 6: Gate Processing	....	....

Under these conditions, there is no definite limiting component. However, it is apparent that track capacity and train arrivals seem to govern the intermodal operation. The model predicts an MPC of about 150,000 TEUs per year. As with the container yard, the intermodal yard can be expected to run efficiently up to about 75 percent of capacity or 112,500 TEUs per year. The model results of the intermodal throughput capacity estimates are presented in **Table II-2**.

TUNNEL CAPACITY

The Port of San Francisco has a unique constraint to its intermodal yard in that the tunnel system limits rail cargo traffic to a few hours of the day. Since an entire train cannot be built within the intermodal yard, cars must be switched from the ICTF a few at a time through the tunnels and connected into full trains at the Bayshore rail yard.

In order to create an operational model of the tunnel and proposed gauntlet track, the system was divided into two major components, the intermodal rail car switching and the commuter rail operations.

For the intermodal component of the model, the track system has been separated into five segments:

- Intermodal container transfer facility
- Siding from 3rd Street to Evans Avenue
- Siding from Evans Avenue to the tunnel gauntlet
- Main line tunnels and gauntlet
- Bayshore rail yard

These five segments have been examined by the model for passage time depending on the length of each string of cars. A summary of the tunnel model is presented in **Table II-3**. The existing commuter train schedule was then plotted on a daily time line and "windows of opportunity" were identified where intermodal train switching could take place. These windows were then compared to the train switching model and the maximum number of cars per day was identified. The results of this study are summarized in **Table II-4**.

Theoretically, each double-stack rail car arriving at an intermodal yard could represent two cars worth of throughput. That is, at five platforms per car and two, 40-foot boxes per platform, each car carries ten 40-foot boxes, or 20 TEUs, to be off-loaded. This leaves an empty car which is available for another 20 TEUs to be loaded out. However, intermodal rail is not always balanced for each port and some portion of the car may arrive (or depart) empty.

For the intermodal rail model of the Port of San Francisco, 150 percent was taken as the ratio of cargo transfer per car. That would correspond to half-loaded cars arriving for export and departing fully loaded with import cargo. Therefore, 1 car X 150% = 30 TEUs. Since the car is switched twice (once in plus once out) there would be 15 TEUs per car, per switch.

Table II-2
Port of San Francisco Intermodal Throughput Capacity Model
ICTF Operations

SUMMARY CAPABILITY ESTIMATES (TEU)

Intermodal Rail Cargo Model Throughput Capability (TEU per Year)	**POSF ICTF**
Component 1: Train Arrival/Departure Activities	148,200
Component 2: Unloading/Loading	151,632
Component 3: Track To Storage Transfer	156,499
Component 4: ICTF Storage	*******************
Component 6: ICTF Gate Processing	149,261
Maximum Practical Throughput Capacity Est.	148,200
Total Storage Acres	0
Total Terminal Acres	35.00
Throughput Capability per Total Acre	4,234
Component Summary Table of Limiting Factors	
Component 1: Train Arrival/Departure Activities	Limiting Component
Component 2: Unloading/Loading	....
Component 3: Track To Storage Transfer	....
Component 4: ICTF Storage	....
Component 6: ICTF Gate Processing	....

Table II-3
Port of San Francisco Intermodal Rail - Tunnel Model
Tunnel Operations

SUMMARY OF CAPACITY ESTIMATES

INPUT	**Switch String 1**	**Switch String 2**	**Switch String 3**
Maximum number of cars in string from ICTF	7	4	3
% of 305' cars in string (relative to total)	25%	25%	25%
Stack train siding speed (mph)	4	4	4
Stack train gauntlet speed (mph)	40	40	40
Stack train yard speed (mph)	10	10	10
Head way time between AMTRAK & stack train	15	15	15
Gauntlet length	11,500	11,500	11,500
Siding length 3rd St. to Evans Ave.	1,500	1,500	1,500
Siding length Evans Ave. to main line	3,500	3,500	3,500
Bayshore yard maximum train length	8,000	8,000	8,000
OUTPUT			
Total possible cars in train (yard limits)	28	28	28
String length (incl. 75' for engine)	2,026	1,190	911
String transit time 3rd St. to Evans Ave.	4	4	4
String transit time Evans to main line	10	10	10
String transit time 3rd OR Evans to main line	14	10	10
String transit time siding to gauntlet	6	3	3
String transit time in gauntlet	3	3	3
String transit time gauntlet to switch yard	2	1	1
Total time 3rd Street is blocked	6	3	3
Total time main line is occupied	25	18	17
Switches required per train	4	7	10
Time window req'd per switch (incl. head way)	40	33	32

Table II-4
Interaction of Commuter Train and Intermodal Train Schedules

• DURATION OF AVAILABLE TIME WINDOW	NUMBER OF CARS IN STRING				
	7	6	[illegible]	1	3
325 Minutes	8				
57 Minutes	1				
33 Minutes				1	
33 Minutes				1	
33 Minutes				1	
33 Minutes				1	
32 Minutes					1
32 Minutes					1
32 Minutes					1
Total Strings	8	0	0	1	3
Total Cars	63	0	0	16	9

Per the calculations in **Table II-4**, the total maximum practical capacity of the tunnel is:

63 7-car strings + 16 4-car strings + 9 3-car strings = 88 cars/day
88 cars X 15 TEUs = 1,320 TEUs/day

Since the most efficient operating capacity of the tunnel is about 75 percent of Maximum Practical Capacity and the tunnel will be operated five days per week, or about 260 days per year:

1,320 TEUs X 75% = 990 TEUs/day
990 TEUs/day X 260 days = 257,400 TEUs/year

Since the terminal and hence, the tunnel must have the capacity to operate during peak demand periods throughout the year, it must necessarily operate at a reduced capacity during the remaining time. This peak is commonly 150 percent of normal throughput. Therefore, the cargo reduction due to the effect of peaking is estimated at 1.50.

257,400 TEUs/ 1.5 = 171,600 TEUs/year

By this, the optimum economic capacity of the tunnel with an interlocked gauntlet track is about **172,000 TEU per year** or about 150 percent of the optimum economic capacity of the intermodal yard. **This means that, with the gauntlet track improvements, the tunnel will not limit the Port's intermodal rail capacity.**

MARKET DEMAND ANALYSIS

WEST COAST CARGO GROWTH FORECASTS AND INTERMODAL TRANSPORT

To understand the demand as well as potential growth of container throughput on the West Coast, three recent studies were reviewed. These include:

- **The West Coast Ports Comparison Study**
  Vickerman·Zachary·Miller, September, 1991
- **WEFA San Pedro Bay Cargo Forecast**
  Wharton Econometrics, June, 1991 (Update)
- **Benefits From Improved Tunnel Clearances**
  Manalytics, January, 1989

West Coast Ports Comparison Study (VZM)

The West Coast Ports Comparison Study is a compilation of published port data and telephone survey information which was normalized for the year 1990. The relevant information from this study is summarized as follows:

- The San Pedro Bay ports have experienced an historical compound annual growth rate (CAGR) in containerized cargo of 7.8 percent between 1985 and 1990.
- The Port of San Francisco has experienced an historical CAGR in containerized cargo of 7.1 percent between 1988 to 1990.
- Containerized cargo volumes at West Coast ports are forecasted to grow at an annual rate of 5.1 percent through the Year 2000.
- The estimated current maximum practical capacity of the Port of San Francisco is 432,000 TEUs per year.
- The proportion of containerized cargo that was transported via intermodal rail at the San Pedro Bay ports was equal to 24 percent in 1990.
- The proportion of containerized cargo that was transported via intermodal rail at the Port of Tacoma was equal to 39 percent in 1990.

The WEFA San Pedro Bay Cargo Forecast

The WEFA San Pedro Bay Cargo Forecast was prepared in 1987 as part of the Ports of Los Angeles and Long Beach 2020 planning study. It was updated in 1991 to reflect the continued shift of break-bulk cargo to containers. Although the WEFA study was specific to the San Pedro Bay ports, the projections and implications are applicable to the San Francisco Bay Area as well. The relevant information is summarized as follows:

- Containerized cargo volumes at the San Pedro Bay Ports have grown at an average annual rate of 11.9 percent from 1980 to 1990.
- Containerized cargo volumes are forecasted to grow at the following annual rates:
    - Low projection: 3.8%
    - High projection: 5.6%
    - Average projection: 4.7%

The forecast growth rates in the WEFA study are not constrained by terminal capacity. Therefore, they represent growth in demand, regardless of whether terminal capacity is improved in coming years.

Benefits From Improved Tunnel Clearances (Manalytics)

The Manalytics tunnel report projected a possible increase of Port volume through the Year 2010, if tunnel improvements were made. The average growth rate implied by these projections is 6.4 percent per year. Other relevant information is summarized as follows:

- The intermodal rail market is projected to be 40 percent of the Port's growth.

- Discretionary (non-local) cargo is projected to be 60 percent of the Port's market.
- A projected 20 percent of the Port's cargo could go by rail if the improvements are made.

Manalytics projects that 20 percent of the containerized cargo could be transported by intermodal rail. This projection is based on the expected growth of local (non-discretionary) cargo. If the Port succeeds in attracting carriers with land-bridge customers, then a higher percentage of intermodal rail cargo could be expected. It is a reasonable assumption that the Port would probably never reach the intermodal rail component of Tacoma (39 percent). However, it is likely that San Francisco would experience a cargo mix similar to that of the San Pedro Bay ports at 24 percent intermodal. **Therefore, we conclude that 25 percent intermodal rail component is likely for the Port of San Francisco if tunnel improvements are made.**

In summary, the following average annual growth projections can be considered for the Port of San Francisco containerized cargo volumes:

- VZM: 5.1% (West Coast)
- WEFA: 4.7% (San Pedro Bay)
- Manalytics: 6.4% (POSF)

In light of current and historical growth trends in containerized cargo, **we conclude that an average annual growth rate of five percent for the Port of San Francisco is both realistic and conservative.**

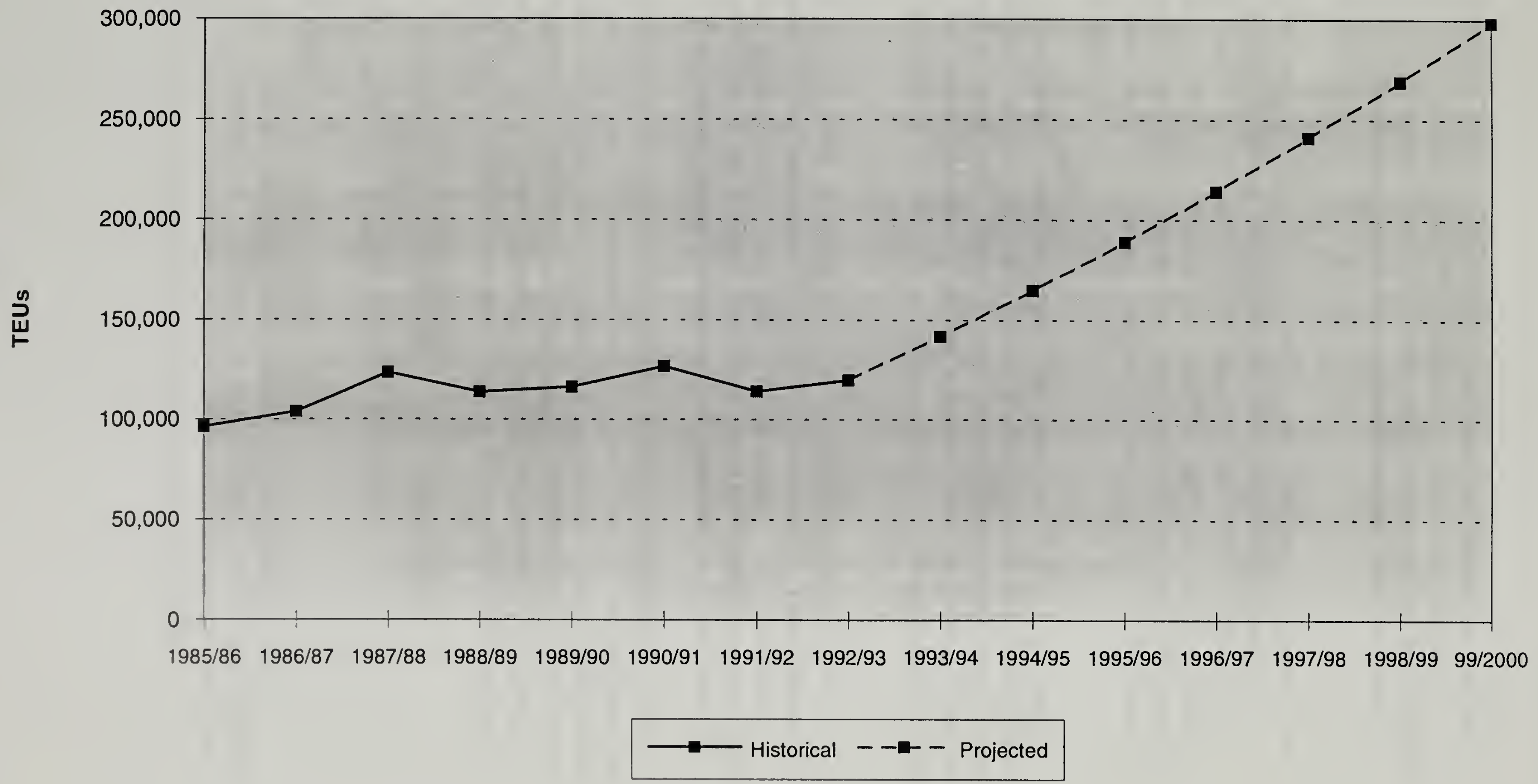
CAPACITY ISSUES RELATIVE TO MARKET DEMAND

An optimum and economically feasible operating capacity for a typical container terminal is about 75 percent of its maximum practical capacity (MPC). Therefore, at the Port of San Francisco, the optimum capacity is 400,000 TEUs/year X 75% = 300,000 TEUs per year. At 25 percent of this volume, an intermodal rail throughput of 75,000 TEUs per year is consistent with both the throughput capabilities of the intermodal yard (112,500 TEUs per year) and of the tunnel system (172,000 TEUs per year).

The Port of San Francisco estimates its current throughput at about 114,000 TEUs per year, excluding transshipment cargo. (Refer to **Figure II-1** for Port cargo volumes over the past five years). The transshipment operation has recently been discontinued, and since the cargo never left the terminal by land, it has not been a candidate for intermodal rail. Because the current throughput at 114,000 TEUs per year is significantly below the Port's cargo handling capacity, an additional short term increase of about 12,000 TEUs per year can be expected at the Port due to potential increases in service levels resulting from underutilized terminal facilities.

To approximate the current market demand for container throughput (without the tunnel improvements) at the Port of San Francisco, this throughput potential must be added to the actual throughput as follows: 114,000 TEUs per year + 12,000 TEUs per year = 126,000 TEUs per year.

Figure II-1
Historical and Projected Cargo Volumes with the Tunnel Improvements (TEUs)
San Francisco Port
Tunnel Economic Impact Analysis



Economic & Planning Systems, Inc 4/22/93

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At an estimated optimum throughput of 300,000 TEUs per year, the current marketable throughput of 126,000 TEUs per year is 174,000 TEUs per year below the optimum throughput. Market demand (in the form of additional cargo volumes at the Port) could fill the remaining capacity if cargo demand grows at five percent per year and the tunnel improvements are constructed.

If the current West Coast cargo throughput of about 9,500,000 TEUs per year grows at the projected five percent CAGR, there will be an estimated 3,867,000 TEUs per year of additional cargo by the Year 2000. Manalytics estimates that 60 percent of this, or about 2,320,000 TEUs, will be discretionary. Discretionary cargo is defined as cargo that is not bound for local destinations and can be moved from one Port to another at the discretion of the shipping line. This growth in discretionary cargo represents the potential uncommitted market for intermodal cargo.

Assuming that San Francisco's cargo volumes grow at the same rate of West Coast cargo volumes (at five percent per year), current cargo volumes will increase from 126,000 TEUs to 170,000 TEUs through the Year 2000. The remaining 130,000 TEUs represent the amount of discretionary cargo the Port would need to capture in order to achieve optimum capacity. This amount represents approximately 5.6 percent of the potential uncommitted West Coast market for cargo.

The San Francisco Port has a number of competitive advantages that could result in capturing a larger share of West Coast cargo demand than it is currently. These advantages include an on-dock intermodal yard, the availability of land, natural deep water, good transportation links and a very strong regional market. Without the tunnel improvements, however, it is unlikely that cargo transport services could be provided at competitive rates.

Based on the Port's competitive advantages and assuming the tunnel improvements are made, it is reasonable to expect that cargo volumes would grow at five percent per year and that the Port could capture 5.6 percent of the West Coast's discretionary cargo. If this were the case, then 75 percent of the maximum practical capacity, or 300,000 TEUs per year could be achieved. As maximum capacities are achieved, labor costs increase due to overtime requirements. Therefore, due to higher labor costs, it may be cost prohibitive to operate at capacities above 300,000 TEUs.

PROJECTED CARGO VOLUMES UNDER EACH SCENARIO

Alternative 1: Loss of Trade

In Alternative 1, the Port would not develop significant intermodal capability. The increasing use of high cube containers would have a significant impact on the capabilities of the intermodal facility. Without improvements to the tunnels so that high cube containers could be accommodated, the intermodal facility would start to become obsolete.

It is reasonable to assume that under this scenario, two carriers would leave the Port when their contracts expire. This would result in a net reduction of about 30,000 TEUs per carrier. This loss of cargo would put the Port at about one-half of its current throughput. In the event that the Port loses one-half of its throughput, it is reasonable to expect that some of this capacity would be absorbed by other carriers due to increased levels of service resulting from the underutilized terminal facilities.

It is estimated that after the two carriers leave, approximately 9,000 TEUs of the loss in cargo could easily be absorbed by existing carriers. Therefore, the base throughput of the Port under Alternative 1 is projected at: 126,000 TEUs per year - (2 X 30,000 TEUs per year) + 9,000 TEUs per year = **75,000 TEUs per year.**

Alternative 2A: Market Capacity (With Rail)

In Alternative 2A, the Port would acquire a significant intermodal capacity and capture 5.6 percent of the projected West Coast discretionary cargo growth. In this case, the marketability of the Port would fix the cargo ceiling at 75 percent of the maximum terminal capacity or **300,000 TEUs per year.**

The intermodal yard would handle 25 percent of the cargo or 75,000 TEUs per year. This is 50 percent of its maximum practical capacity and, therefore, is generally consistent with the other projections. The rail tunnel would have a capacity of 172,000 TEUs per year with the proposed modifications. Therefore, it would not limit cargo throughput.

Alternative 2B: Market Capacity (With Drayage)

In Alternative 2B, the Port would maintain a significant intermodal capacity through drayage to existing off-port intermodal container transfer facilities. This scenario also would allow the Port to capture 5.6 percent of the projected West Coast discretionary cargo growth, equaling **300,000 TEUs per year.** It is assumed that the additional costs of drayage compared to on-dock intermodal transport would not be borne by the carriers and therefore would not affect their decisions to call at the Port.

PROJECTED MODE SPLIT

The two surface transportation modes compared in this study are double-stacked rail and diesel trucks. For both rail and truck transportation modes, "local" cargo is defined as cargo which remains within the Bay Area and is best handled by local ports. "Non-local" cargo is defined as cargo which originates or is destined for points which may be within the market area of several ports, including Bay Area ports. On average, non-local cargo is estimated to travel approximately 60 miles within the boundaries of the Bay Area. This information is utilized in the analysis of air quality impacts in **Chapter IV**.

Alternative 1: Loss of Trade

In Alternative 1, the current mode split and local cargo growth would determine the future cargo destinations. The Manalytics report projects that only 20 percent of San Francisco cargo would be discretionary and currently, only five percent of the cargo would go by rail. Therefore, cargo volumes equal to 75,000 TEUs per year would be transported as follows:

- 80% or 60,000 TEUs per year would be trucked to local destinations.
- 15% or 11,250 TEUs per year would be trucked to non-local destinations.
- 5% or 3,750 TEUs per year would travel by rail to non-local destinations.

This results in an overall mode split of 95 percent truck, five percent rail.

Alternative 2A: Market Capacity (With Rail)

In Alternative 2A, cargo volumes would be equal to 300,000 TEUs per year. Of this, 60 percent would be discretionary and 40 percent would be local. The portion of the 300,000 TEUs per year which would be transported by intermodal rail is estimated at 25 percent, or about 75,000 TEUs, per year and would travel directly from the on-dock intermodal yard. Therefore, cargo volumes equal to 300,000 TEUs per year would be transported as follows:

- 40% or 120,000 TEUs per year would be trucked to local destinations.
- 35% or 105,000 TEUs per year would be trucked to non-local destinations.
- 25% or 75,000 TEUs per year would travel by rail to non-local destinations.

This results in an overall mode split of 75 percent truck, 25 percent rail.

Alternative 2B: Market Capacity (With Drayage)

In Alternative 2B, cargo volumes would be equal to 300,000 TEUs per year. Of this, 60 percent would be discretionary and 40 percent would be local. The portion of the 300,000 TEUs per year which would be transported by intermodal rail is estimated at 25 percent, or about 75,000 TEUs per year, and would be drayed to other Bay Area intermodal yards. Therefore, cargo volumes equal to 300,000 TEUs per year would be transported as follows:

- 40% or 120,000 TEUs per year would be trucked to local destinations.
- 35% or 105,000 TEUs per year would be trucked to non-local destinations.
- 20% or 60,000 TEUs per year would be drayed to remote intermodal yards.
- 5% or 15,000 TEUs per year would travel by rail to non-local destinations.

This results in an overall mode split of 95 percent truck, five percent rail.

III. ECONOMIC IMPACTS

This chapter analyzes and compares the direct, indirect and induced economic impacts generated by containerized cargo shipping and related Port businesses under the "no tunnel improvements" and "tunnel improvements" scenarios. A discussion of the assumptions and methodology utilized in this analysis is followed by definitions of direct, indirect, and induced economic impacts. Next, a summary of the employment, revenue, payroll, and local tax revenues generated under each scenario is presented.

METHODOLOGY

For initial estimates of employment, revenues, and payroll, EPS relied on an economic impact study prepared for the Port of San Francisco by Trade Information Planning Systems in September, 1988 (hereafter referred to as the "POSF Economic Impact Study"). We translated the base economic data into employment, revenues, and payroll per 1,000 TEUs (twenty-foot equivalent units) of containerized cargo based on current Port cargo volumes. We then converted the per 1,000 TEUs information into total employment, revenue and payroll data based on estimates of future containerized cargo volumes under each of the alternatives.

Cargo volumes under each of the scenarios were estimated by evaluating and synthesizing, where appropriate, previous market analysis conducted by Vickerman-Zachary-Miller (VZM) and other marine planning firms. This information was supplemented by a throughput analysis prepared by VZM, which is discussed in **Chapter II**.

For certain cargo handling businesses or activities (specifically, stevedoring/longshore and surface transportation), we adjusted employment, revenue, and payroll figures based on additional research conducted regarding the employment characteristics of the container terminals and intermodal facility, and based on changes in the transportation mode split (e.g. truck vs. rail) under each alternative.

To quantify indirect and induced impacts, we applied the economic multipliers utilized in the POSF Economic Impact Study to the adjusted direct employment, revenue, and payroll data. The multipliers in the POSF Economic Impact Study were derived from running the Port Economic Input/Output Model developed by the American Association of Port Authorities and the United States Maritime Administration, calibrated to City of San Francisco economic data inputs.

Employment figures are measured in full-time equivalents (FTEs), so that part-time employees are not counted as one "full" employee. Revenue and payroll figures were adjusted for inflation in order to reflect 1993 dollars. Tax revenues were estimated based on information derived from city officials regarding the tax rates and collection procedures for local taxes.

DIRECT, INDIRECT AND INDUCED IMPACTS

DIRECT ECONOMIC IMPACTS

For each alternative, direct economic impacts, including employment, payroll, gross revenues, and local tax revenues are quantified. Direct economic impacts are those which are directly associated with Port-related operations. Three primary categories of direct economic impacts have been quantified: 1) cargo handling activities; 2) Port users; and 3) capital expenditures.

Cargo Handling

Examples of businesses and/or activities which are involved in the handling of cargo include stevedoring companies, navigational services, container stuffing and warehousing, inland transportation and drayage such as trucking and rail, and government/regulatory services. (A complete categorization of businesses and/or activities is provided in **Table III-1**). The tunnel improvements will directly affect the containerized cargo trade. Therefore, this study focuses on the change in economic impacts due to changes in **container** cargo volumes under the "no tunnel improvements" and "tunnel improvements" scenarios.

Port Users

In addition to businesses engaged in containerized cargo handling activities, direct economic impacts are also generated by businesses which extensively utilize the Port to ship or receive goods. The POSF Economic Impact Study identified major exporters and importers for which economic impacts were quantified, including high technology firms, coffee roasting manufacturers, apparel manufacturers, and newspaper printing. With the exception of newspaper printing, these goods are typically transported in containers. Therefore, this study quantifies the direct economic impacts generated by these identified Port users.

Capital Expenditures

The third categorization of direct economic impacts is generated from Port-related capital expenditures. In this analysis, we have focused on capital expenditures which are related directly to containerized cargo operations.

The capacity analysis conducted by VZM indicated that the cargo volumes as outlined in Alternatives 2A and 2B (300,000 TEUs) can be achieved without additional improvements to the container terminals or to the intermodal container transfer facility. However, in keeping with its commitment to improve its intermodal capabilities, the Port has recently funded several projects which are currently underway. These projects include:

- ongoing improvements at Pier 80 including heightening portions of the facility in order to create a uniform grade;
- heightening two cranes by 17 feet at Piers 94 and 96 to accommodate fourth generation container ships;

Table III-1
Estimated Annual Direct Employment (FTEs) from Containerized Cargo Operations
Tunnel Economic Impact Analysis

Category	Estimated Base Per 1,000 TEU (1)	Alternative 1 (2)	Alternative 2A (2)	Incremental Change
Cargo Volume (TEUs) (3)		75,000	300,000	225,000
Navigational Services	0.31	23	93	70
Stevedoring/Longshore	1.80	135	540	405
Container Stuffing and Warehousing	0.22	16	65	49
Surface Transportation				
Truck (4)	1.92	183	576	394
Rail (4), (5)	0.55	12	248	235
Port charges	0.61	46	184	138
Other Government	0.82	62	246	185
Supplies and Bunkers	0.04	3	12	9
Minor Repairs	0.07	5	22	16
Steamship Agency Commissions	1.16	87	349	262
Freight Forwarders and Customs Brokers	0.86	65	259	194
Banking and Insurance	0.74	55	221	166
Total	9.11	693	2,816	2,123

(1) In general, Base employment per 1,000 TEUs is based on the POSF Economic Impact Report, dated Sept. 1988, prepared by Trade Information Planning Systems; modifications have been made to the following categories: Stevedoring/Longshore, Intermodal Facility, Truck and Rail.
(2) The employment estimates for Alternatives 1 and 2A are derived by applying base employment per 1,000 TEUs to estimates of cargo volumes under each scenario.
(3) Twenty-foot equivalent units.
(4) Mode splits for Alternative 1 are 95% truck, 5% rail; for Alternative 2A: 75% truck, 25% rail; employment figures for truck and rail are modified under each scenario based on the mode split.
(5) Includes intermodal yard employees.

Source: Trade Information Planning Systems, Port of San Francisco, Vickerman-Zachary-Miller, Economic & Planning Systems, Inc.

- quadrupling the capacity of the refrigerated container handling facilities;
- placing utilities underground to facilitate more efficient terminal operations; and
- constructing two marine buildings for the longshoremen's use.

Because these improvements are underway and would occur under both the "no tunnel" and "tunnel" scenarios, we have not included the costs of the improvements in this analysis.

It is possible that container shipping lines may opt to purchase additional equipment such as cranes or hostlers to facilitate the transfer of cargo. Since this is a relatively uncertain assumption, for the purposes of this analysis, we have assumed no capital expenditures by the shipping lines.

INDIRECT AND INDUCED IMPACTS

Indirect impacts are generated as a result of Port-related businesses purchasing labor, supplies and materials from other firms or from independent contractors. Persons directly employed by Port-related businesses generate induced impacts when they spend their disposable income on goods and services such as food, housing, transportation, etc. Indirect and induced impacts are typically quantified by utilizing multipliers derived from input/output economic models. For this analysis, we have relied on the economic multipliers generated in the POSF Economic Impact Study, as discussed above.

SUMMARY OF ECONOMIC IMPACTS

CARGO VOLUMES AND MODE SPLITS UNDER EACH SCENARIO

Chapter II outlines the underlying market and capacity assumptions utilized to estimate cargo volumes under each scenario. To summarize, Alternative 1 assumes that the tunnel improvements are not made; as a result, San Francisco cargo volumes decrease from 114,000 TEUs currently to an estimated 75,000 TEUs. The transportation mode split under this scenario is assumed to be 95 percent truck and 5 percent rail, based on the current mode split as estimated by Port staff.

Cargo volumes in Alternative 2A are based on market demand for the Port's facilities given West Coast cargo growth forecasts, the Port's competitive position in the marketplace, and the assumption that the height constraints of the tunnels are removed. In this alternative, cargo volumes are estimated to increase to 300,000 TEUs. Due to improvements made to the tunnels, it is assumed under this scenario that 75 percent of containerized cargo is transported from the Port by truck and 25 percent is transported by rail. This mode split is consistent with other West Coast ports which used intermodal rail facilities.

In Alternative 2B, it is assumed that the cargo volumes outlined in the market demand scenario (300,000 TEUs) are achieved. Because the tunnel improvements are not made, the cargo volumes are transported primarily by truck (the mode split is equal to 95 percent

truck, 5 percent rail). While this is physically possible based on the operating capacity of the Port's facilities, it may be cost-prohibitive, due to the inefficiencies and expense of drayage compared to double-stacked rail intermodal transport. Alternatives 2A and 2B provide a comparable basis for measuring and analyzing air quality impacts under similar, market-based scenarios.

Therefore, from an economic impact perspective, the analysis in this chapter will focus on a comparison of the "no tunnel improvements" and "tunnel improvements" scenarios as presented in Alternatives 1 and 2A. The comparative analysis of air quality impacts between Alternatives 2A and 2B is discussed in **Chapter IV**.

EMPLOYMENT

Containerized Cargo

Table III-1 estimates annual direct employment generated from containerized cargo activities under Alternatives 1 and 2A. Current container cargo volumes generate an estimated 9.11 employees per 1,000 TEUs, which translates into 693 cargo-related employees (measured in full-time equivalents) in Alternative 1 and 2,816 employees in Alternative 2A. There would be an annual incremental gain equal to 2,123 cargo-related employees, if improvements to the tunnels are made.

Port Users

Additional annual direct employment generated by businesses which import and export goods is outlined in **Table III-2**. Based on an estimated ratio of 5.06 employees per 1,000 TEUs, 379 employees are generated in Alternative 1 and 1,517 employees in Alternative 2A. (Because no distinction is made regarding employees generated by transportation mode, as there is with cargo handling, no adjustments were made based on mode splits [e.g. truck vs. rail] for Port users). The incremental difference between making the tunnel improvements and not making the improvements is equal to 1,138 full-time employees.

Tunnel Improvements

Table III-3 estimates additional employment generated based on the anticipated cost of the tunnel improvement project. According to Port staff, the preliminary cost of the tunnel project is approximately $11 million. Based on total payroll estimates of $2.2 million and an average salary per construction worker of $39,126, there would be 56 additional employees in Alternative 2A. The construction-related employees generated from the tunnel project are short-term, as opposed to permanent, employees.

Since the employment generated from cargo handling and Port uses represents employment during a one-year period, we have included the construction employees in the total employment figures. This is also the case for revenues and payroll generated from the tunnel project, as discussed in subsequent sections of this chapter.

Table III-2
Estimated Annual Direct Employment from Port Users Tunnel Economic Impact Analysis

Type of Firm	Estimated Base Per 1,000 TEU (1)	Alternative 1 (2)	Alternative 2A (2)	Incremental Change
Cargo Volumes		75,000	300,000	225,000
High Tech	1.25	93	374	280
Coffee	1.25	93	374	280
Apparel Manufacturing	2.56	192	769	577
Total	**5.06**	**379**	**1,517**	**1,138**

(1) Base employment per 1,000 TEUs is based on the POSF Economic Impact Report, dated 1988.
(2) The employment estimates for Alternatives 1 and 2A are derived by applying employment per 1,000 TEUs from the base employment figures to estimates of cargo volumes under different scenarios.

Source: Trade Information Planning Systems, Economic & Planning Systems, Inc.

Table III-3
Estimated Direct Employment from Tunnel Improvements
Tunnel Economic Impact Analysis

Item	Alternative 1	Alternative 2A	Incremental Change
Total Cost (1)	**$0**	**$11,000,000**	**$11,000,000**
Total Payroll (2)	**$0**	**$2,200,000**	**$2,200,000**
Total Employment (3)	**0**	**56**	**56**

(1) Based on preliminary Port cost estimates.
(2) Estimated at 20% of total cost, per the POSF Economic Impact Report, dated 1988.
(3) Estimated average salary of $39,126, per the POSF Economic Report, adjusted for inflation; employment is construction-related and short term.

Source: Trade Information Planning Systems, Port of San Francisco,
Economic & Planning Systems, Inc.

Total employment impacts are summarized in **Table III-4**. Direct and indirect employment generated from containerized cargo handling, Port users, and construction of the tunnel improvements results in 1,896 employees in Alternative 1 and 7,756 employees in Alternative 2A. This equates to an incremental gain of 5,859 full-time employees, if improvements to the tunnels are made.

REVENUES

Containerized Cargo

The estimated direct annual revenues from containerized cargo operations is outlined in **Table III-5** (revenues are shown in thousands of dollars). Revenue generated per 1,000 TEUs is estimated at $884.13, equating to approximately $67 million in Alternative 1 and $265 million in Alternative 2A. This results in an incremental gain of $198 million in annual revenues under the "tunnel improvements" scenario.

Port Users

Table III-6 summarizes annual revenue generated from Port users who import and export containerized cargo. With revenues estimated at $565.62 per 1,000 TEUs, direct revenues generated from Port users equals $42 million in Alternative 1 and $170 million in Alternative 2A. The incremental difference in annual revenues between the "no tunnel improvements" and "tunnel improvements" scenarios is equal to $127 million.

Tunnel Improvements

The cost of the tunnel improvement project translates into revenues for businesses providing the supplies and materials. Therefore, the "revenue" generated from the tunnel project is equal to the estimated cost, at $11 million (see **Table III-3**). This revenue applies only in the case of Alternative 2A, where it is assumed that the tunnel project is built.

Total direct and indirect revenues are summarized in **Table III-7.** Alternative 1 generates $110 million in revenues compared to $453 million in Alternative 2A. The incremental difference between the "no tunnel improvements" and "tunnel improvements" alternatives is equal to approximately $343 million in annual revenues to the Port and related businesses.

PAYROLL

Containerized Cargo

Table III-8 outlines annual payroll generated from containerized shipping activities. Based on payrolls estimated at $295.75 per 1,000 TEUs, $22 million in payroll revenue is generated in Alternative 1, and $89 million is generated in Alternative 2A.

Table III-4
Estimated Total Annual Direct and Indirect Employment
Tunnel Economic Impact Analysis

Employment	Alternative 1	Alternative 2A	Incremental Change
Direct Employment			
Cargo Operations	693	2,816	2,123
Port Users	379	1,517	1,138
Tunnel Improvements (1)	0	56	56
Subtotal	1,072	4,389	3,317
Multipliers (2)			
Cargo Operations	1.79	1.79	NA
Port Users	1.73	1.73	NA
Tunnel Improvements	1.62	1.62	NA
Total Direct, Indirect and Induced Employment			
Cargo Operations	1,240	5,040	3,800
Port Users	656	2,625	1,968
Tunnel Improvements	0	91	91
Total	**1,896**	**7,756**	**5,859**

(1) Employment related to the tunnel improvements is short-term, not on-going on an annual basis.
(2) Multipliers are derived from the POSF Economic Impact Report, dated 1988.

Source: Trade Information Planning Systems, Port of San Francisco, Vickerman-Zachary-Miller, Economic & Planning Systems, Inc.

Table III-5
Estimated Annual Direct Revenue from Containerized Cargo Operations
Tunnel Economic Impact Analysis

Category	Estimated Base Per 1,000 TEU (1)	Revenue ($000) Alternative 1 (2)	Revenue ($000) Alternative 2A (2)	Revenue ($000) Incremental Change
Cargo Volume (TEUs) (3)		75,000	300,000	225,000
Navigational Services	$40.46	$3,034	$12,137	$9,102
Stevedoring/Longshore	185.48	13,911	55,643	41,732
Container Stuffing and Warehousing	27.89	2,092	8,367	6,275
Surface Transportation				
Truck (4)	157.93	15,004	47,380	32,376
Rail (4)	43.75	656	13,126	12,470
Port charges (5)	57.69	4,326	17,306	12,979
Other Government	88.62	6,647	26,586	19,940
Supplies and Bunkers	83.07	6,230	24,921	18,691
Minor Repairs	7.21	541	2,164	1,623
Steamship Agency Commissions	62.75	4,707	18,826	14,120
Freight Forwarders and Customs Brokers	69.73	5,230	20,918	15,689
Banking and Insurance	59.55	4,466	17,865	13,399
Total	$884.13	$66,843	$265,239	$198,396

(1) Base revenue figures are based on the POSF Economic Impact Report, dated Sept. 1988, prepared by Trade Information Planning Systems, adjusted for inflation (1993 $).

(2) The revenue estimates for Alternatives 1 and 2A are derived by applying base revenue per 1,000 TEUs to estimates of cargo volumes under each scenario.

(3) Twenty-foot equivalent units.

(4) Mode splits for Alternative 1 are 95% truck, 5% rail; for Alternative 2A: 75% truck, 25% rail; revenues for truck and rail are modified under each scenario based on the mode split.

(5) Includes wharfage, dockage, crane rental and other related Port charges.

Source: Trade Information Planning Systems, Port of San Francisco, Vickerman-Zachary-Miller, Economic and Planning Systems, Inc.

Table III-6
Estimated Annual Direct Revenue from Port Users
Tunnel Economic Impact Analysis

		Revenue ($000)		
Type of Firm	**Estimated Base Per 1,000 TEU (1)**	**Alternative 1 (2)**	**Alternative 2A (2)**	**Incremental Change**
Cargo Volumes		75,000	300,000	225,000
High Tech	$170.46	$12,784	$51,137	$38,353
Coffee	$160.91	$12,068	$48,273	$36,205
Apparel Manufacturing	$234.26	$17,569	$70,277	$52,708
Total	**$565.62**	**$42,422**	**$169,687**	**$127,265**

(1) Base revenue figures are based on the POSF Economic Impact Report, dated 1988, adjusted for inflation (1993 $).

(2) The revenue estimates for Alternatives 1 and 2A are derived by applying Base revenue per 1,000 TEUs to estimates of cargo volumes under each scenario.

Source: Trade Information Planning Systems, Economic and Planning Systems, Inc.

Table III-7
Estimated Total Annual Direct and Indirect Revenues Tunnel Economic Impact Analysis

Revenues ($000)	Alternative 1	Alternative 2A	Incremental Change
Direct Revenues ($000)			
Cargo Operations	$66,843	$265,239	$198,396
Port Users	0	0	0
Generated from Tunnel Improvements (1)	0	11,000	11,000
Subtotal	$66,843	$276,239	$209,396
Multipliers (2)			
Cargo Operations	1.65	1.65	NA
Port Users	1.45	1.45	NA
Generated from Tunnel Improvements	1.43	1.43	NA
Total Direct, Indirect and Induced Revenues			
Cargo Operations	$110,291	$437,645	$327,354
Port Users	0	0	0
Generated from Tunnel Improvements	0	15,730	15,730
Total	**$110,291**	**$453,375**	**$343,084**

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(1) See Table III-3 for estimates of revenue generated from the tunnel improvements; revenue related to the tunnel improvements is short-term, not on-going on an annual basis.

(2) Multipliers are derived from the POSF Economic Impact Report, dated 1988.

Source: Trade Information Planning Systems, Port of San Francisco, Vickerman-Zachary-Miller, Economic and Planning Systems, Inc.

Table III-8
Estimated Annual Direct Payroll from Containerized Cargo Operations
Tunnel Economic Impact Analysis

Category	Estimated Base Per 1,000 TEU (1)	Payroll ($000) Alternative 1 (2)	Payroll ($000) Alternative 2A (2)	Payroll ($000) Incremental Change
Cargo Volume (TEUs) (3)		75,000	300,000	225,000
Navigational Services	$28.12	$2,109	$8,436	$6,327
Stevedoring/Longshore	40.55	3,041	12,165	9,124
Container Stuffing and Warehousing	6.97	523	2,092	1,569
Surface Transportation				
Truck (4)	55.27	5,251	16,582	11,331
Rail (4)	18.28	274	5,483	5,209
Port charges	26.40	1,980	7,921	5,941
Other Government	26.59	1,994	7,977	5,983
Supplies and Bunkers	1.33	100	398	299
Minor Repairs	2.88	216	865	649
Steamship Agency Commissions	37.65	2,824	11,296	8,472
Freight Forwarders and Customs Brokers	27.89	2,092	8,367	6,275
Banking and Insurance	23.81	1,786	7,144	5,358
Total	$295.75	$22,190	$88,726	$66,535

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(1) Base payroll figures are based on the POSF Economic Impact Report, dated Sept. 1988, prepared by Trade Information Planning Systems, adjusted for inflation (1993 $).

(2) The payroll estimates for Alternatives 1 and 2A are derived by applying Base payroll per 1,000 TEUs to estimates of cargo volumes under each scenario.

(3) Twenty-foot equivalent units.

(4) Mode splits for Alternative 1 are 95% truck, 5% rail; for Alternative 2A: 75% truck, 25% rail; revenues for truck and rail are modified under each scenario based on the mode split.

Source: Trade Information Planning Systems, Port of San Francisco, Vickerman-Zachary-Miller, Economic and Planning Systems, Inc.

Port Users

Port users generate $11 million in annual payroll revenue in Alternative 1 and $45 million in Alternative 2A (see **Table III-9**). This represents an incremental gain of $33 million in annual payroll revenues, if improvements to the tunnel are made.

Tunnel Improvements

Based on 20 percent of the project cost being attributed to labor, the tunnel improvement project generates $2.2 million in short-term, construction payroll revenues (see **Table III-3**). Total direct and indirect annual payroll revenues are summarized in **Table III-10**. Payroll generated from containerized cargo operations, port users and the tunnel improvements equal $54 million in Alternative 1 and $218 million Alternative 2A, or $165 million in additional annual payroll revenues if the tunnel improvements are made.

LOCAL TAX REVENUES

Local San Francisco tax revenues were estimated based on information derived from city officials regarding the tax rates and collection procedures for local taxes. In addition to the taxes identified and quantified below, other local taxes were examined, including utility tax, business registration tax and possessory interest tax. For the purposes of this study, we limited the analysis to tax revenues that would generate a significant amount of local revenue, namely payroll expense, business, and sales taxes.

As discussed earlier, we have assumed no capital expenditures made by the Port or its tenants other than the tunnel improvements. For that reason, no possessory interest tax revenues are anticipated, since the tunnel improvements are being constructed on Port and/or government-owned property.

Payroll Expense Tax

Payroll expense tax is assessed on local, non-government (which includes the Port) employees. The proportion of local, non-government employees is estimated at 60 percent of the Port-related workforce. Total annual payroll tax, therefore, based on a rate of 1.5 percent of local, non-government payroll is equal to $297,000 in Alternative 1 and $1.2 million in Alternative 2A (see **Table III-11**).

Business Tax

Business tax is assessed on local, non-government revenue, which is also estimated to be approximately 60 percent of total revenues generated by Port-related businesses. Business tax rates range from $1.23 to $3.00 per $1,000 of gross receipts, depending on business tax classifications. A review of the tax rates indicates that most of the Port-related businesses fall into the $3.00 tax rate category. Total annual business tax, therefore, equals $120,000 in Alternative 1 and $497,000 in Alternative 2A.

Table III-9
Estimated Annual Direct Payroll from Port Users
Tunnel Economic Impact Analysis

Type of Firm	Estimated Base Per 1,000 TEU (1)	Payroll ($000) Alternative 1 (2)	Payroll ($000) Alternative 2A (2)	Payroll ($000) Incremental Change
Cargo Volumes		75,000	300,000	225,000
High Tech	$51.14	$3,836	$15,343	$11,507
Coffee	$48.27	$3,620	$14,482	$10,861
Apparel Manufacturing	$49.43	$3,707	$14,828	$11,121
Total	**$148.84**	**$11,163**	**$44,652**	**$33,489**

(1) Base revenue figures are based on the POSF Economic Impact Report, dated 1988, adjusted for inflation (1993 $).

(2) The payroll estimates for Alternatives 1 and 2A are derived by applying Base payroll per 1,000 TEUs to estimates of cargo volumes under each scenario.

Source: Trade Information Planning Systems, Economic and Planning Systems, Inc.

Table III-10
Estimated Total Annual Direct and Indirect Payroll
Tunnel Economic Impact Analysis

Payroll ($000)	Alternative 1	Alternative 2A	Incremental Change
Direct Payroll			
Cargo Operations	$22,190	$88,726	$66,535
Port Users	11,163	44,652	33,489
Tunnel Improvements (1)	0	2,200	2,200
Subtotal	$33,353	$135,578	$102,225
Multipliers (2)			
Cargo Operations	1.62	1.62	NA
Port Users	1.59	1.59	NA
Tunnel Improvements	1.66	1.66	NA
Total Direct, Indirect and Induced Payroll			
Cargo Operations	$35,948	$143,735	$107,787
Port Users	17,749	70,997	53,248
Tunnel Improvements	0	3,652	3,652
Total	**$53,698**	**$218,385**	**$164,687**

(1) See Table III-3 for estimates of payroll generated from the tunnel improvements; payroll related to the tunnel improvements is short-term, not on-going on an annual basis.
(2) Multipliers are derived from the POSF Economic Impact Report, dated 1988.

Source: Trade Information Planning Systems, Port of San Francisco, Vickerman-Zachary-Miller, Economic and Planning Systems, Inc.

Table III-11
Estimated Total Annual Local Tax Revenues (1)
Tunnel Economic Impact Analysis

Type of Tax ($000)	Alternative 1	Alternative 2A	Incremental Change
Payroll Tax			
Direct Payroll (see Table III-10)	$33,000	$135,578	$102,578
Percentage of Local, Non-Government Jobs (2)	60%	60%	60%
Payroll Tax Rate	1.50%	1.50%	1.50%
Total Payroll Tax	$297	$1,220	$923
Business Tax			
Direct Gross Receipts (see Table III-7)	$66,843	$276,239	$209,396
Percentage of Local, Non-Government Revenue (3)	60%	60%	60%
Business Tax Rate per $1,000 (4)	$3.00	$3.00	$3.00
Total Business Tax	$120	$497	$377
Local Share of Sales Tax (5)			
Direct Employee Payroll (see Table III-10)	$33,353	$135,578	$102,225
Total Employee Expenditures (6)	$29,351	$119,309	$89,958
Employee Taxable Expenditures (7)	$10,860	$44,144	$33,284
Local Capture of Employee Taxable Expenditures (8)	$2,172	$8,829	$6,657
Local Sales Tax Rate	1.25%	1.25%	1.25%
Local Share of Sales Tax	$27	$110	$83
Total Local Tax Revenues	**$444**	**$1,828**	**$1,383**

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(1) In 1993 dollars.
(2) Payroll tax is not assessed on government or non-local employees; estimate of the proportion of local, non-goverment jobs is from the POSF Economic Impact Study, dated Sept. 1988.
(3) Business tax is not assessed on government or non-locally generated revenues; estimate of the proportion of local, non-goverment-related revenue is from the POSF Economic Impact Study, dated Sept. 1988.
(4) Business tax rates vary by type of business, ranging from $1.23 to $3.00 per $1,000; the majority of Port-related businesses fall under the $3.00 tax rate.
(5) Local sales tax estimates are derived from retail expenditures made from direct, local Port-related employees.
(6) Estimated at 88% of total income, based on Bureau of Labor Statistics data.
(7) Estimated at 37% of total expenditures, based on Bureau of Labor Statistics data.
(8) Estimated at 20%, based on previous EPS retail analyses.

Sources: Dinwiddie & Associates, Trade Information Planning Systems, Port of San Francisco, Vickerman-Zachary-Miller, Bureau of Labor Statistics, Economic and Planning Systems, Inc.

Local Share of Sales Tax

Sales tax was calculated on the taxable expenditures made by direct, local Port-related employees. Employee expenditures are estimated at 88 percent of total employee payroll, (shown in **Table III-10**). Taxable expenditures are estimated at 37 percent of total employee expenditures, based on Bureau of Labor Statistics data for the San Francisco area. Assuming 20 percent of these expenditures were made in San Francisco by local employees results in $27,000 of annual local sales tax revenues in Alternative 1 and $110,000 in Alternative 2A, based on a local share of State sales tax of 1.25 percent.

IV. AIR QUALITY IMPACTS

This chapter analyzes and compares regional air quality effects that would be generated under the "tunnel improvements" and "no tunnel improvements" scenarios. The chapter provides a brief overview of regional air quality issues; describes pollutant characteristics/sources; discusses the assumptions and methodology used in the analysis; compares pollutant emissions for each alternative; and, lastly, summarizes the conclusions of the analysis.

INTRODUCTION

Air quality issues are primarily concerned with public health, and secondarily with public welfare from effects such as visibility reduction, nuisance and other forms of damage.

The project is within the Bay Area Air Basin, which is operated and governed by the Bay Area Air Quality Management District (BAAQMD). Within the Air Basin, State and federal air quality standards for nitrogen oxide, sulfur dioxide, and lead are met. Standards for other pollutants such as ozone, carbon monoxide, and suspended particulates (PM-10) are not met in at least a portion of the Air Basin. The primary source of air pollutant emissions within the Bay Area Air Basin is from vehicular traffic.

POLLUTANT CHARACTERISTICS

A description of the characteristics, major sources and health effects of major pollutants follows.

Ozone (O_3) is the most prevalent of a class of photochemical oxidants formed in the urban atmosphere. It is a nearly colorless gas which irritates the lungs and damages materials and vegetation. It is formed by a photochemical reaction (e.g., when nitrogen dioxide is broken down by sunlight).

Hydrocarbon (HC) is a reactive organic gas that is produced by petrochemicals, natural gas and coal. It reacts with nitrogen oxide and oxygen to form ozone.

Carbon monoxide (CO) is a colorless, odorless toxic gas. At high concentrations, it interferes with the transfer of oxygen to the brain, causing heart difficulties, reduced lung capacity and impaired mental abilities. It is produced by the incomplete combustion of carbon-containing fuels (vehicular exhaust).

Nitrogen oxide (NO) is a yellowish-brown gas which, at high levels, can cause breathing difficulties. It is one of the oxides that results from combustion, and is formed when nitric oxide (pollutant from burning processes) combines with oxygen.

Sulfur dioxide (SO_2) is a colorless gas with a sharp, irritating odor. It is emitted by automobiles, trucks and stationary sources such as power plants.

Suspended Particulates (PM_{10}) are particulate matter less than 10 microns in diameter. It causes a greater health risk than larger sized particles, since these fine particles can more easily penetrate the defenses of the human respiratory system and cause irritation by themselves and in combination with gases.

Sources of these pollutants include truck vehicle and train exhaust and vary according to speed, type of engine (gasoline or diesel), the length of use, and the power available.

ASSUMPTIONS AND METHODOLOGY

This air quality analysis compares the pollutant emissions that would be generated by truck and train trips under two scenarios. Alternative 2A, the tunnel alternative (with rail) assumes that tunnel improvements are made which would allow the use of intermodal trains directly from the Port of San Francisco to various points inland. This alternative would eliminate the truck trips (required under Alternative 2B) to move cargo from the Port of San Francisco to the Port of Oakland or the Port of Richmond.

Alternative 2B, the no tunnel alternative (with drayage) assumes that market capacity would be similar to that of Alternative 2A, however no tunnel improvements are made. Thus, trucks would become the primary means of freight transportation from the Port of San Francisco to intermodal facilities at the Ports of Oakland and Richmond. Intermodal trains would then be used to move cargo from the Port of Oakland and the Port of Richmond to destination points inland. The estimated truck and train trips under each scenario are summarized in **Table IV-1**.

TRUCK EMISSIONS

The air quality analysis compares the mobile emissions generated by trucks and trains for each scenario. The air pollutant emissions from truck and train trips are estimated using the California Air Resources Board's (CARB) Locomotive Emissions Study and the U.S. Environmental Protection Agency's Compilation of Air Pollutant Emission Factors (AP-42). The variables used in this analysis are summarized in **Table IV-1**.

Truck emission rates and estimates are based on the following assumptions:

1) Only heavy duty diesel trucks are in use.
2) All trucks are 8,500 pounds or more.
3) Trucks are relatively new (1993-1996 model) and have less than 50,000 mileage.
4) Average local truck trip is 30 miles.

Table IV-1
Daily Truck and Train Trips
Tunnel Air Quality Impact Analysis

Transportation Mode	Alternative 2A	Alternative 2B
Rail Activity		
I. Switch Train Trips from Bayshore Yard to Port of San Francisco	(3) 7-car switch train trips (1) 3-car switch train trip (1) deadhead move	None
II. Intermodal Train Trip	(1) 24-car intermodal train trip from Port of San Francisco to points inland.	(1) 24-car intermodal train trip from Port of Oakland or Port of Richmond to points inland.
Truck Activity		
I. Inter-Port Trips	None	340 truck trips from Port of San Francisco to Port of Oakland or Port of Richmond.
II. Highway Trips	412 truck trips (local) 630 truck trips (non-local)	412 truck trips (local) 630 truck trips (non-local)

Source: Vickerman-Zachary-Miller, 1993.

5) Average non-local truck trip is 60 miles within the Bay Area Air Quality Basin. (Although non-local trips would have longer distances, only the average distance within the Air Basin is considered for the purposes of this analysis).
6) Average distance from Port of San Francisco to Port of Richmond or Port of Oakland is 15 miles.
7) Test speed is 20 miles per hour (mph) with a speed correction factor applied for an average speed of 25 mph.
8) Ambient temperature is 75° Fahrenheit.
9) Idle emissions are estimated in the hot stabilized mode.
10) Average idling time is estimated at 30 minutes per truck trip (see also **Table IV-2**).

The rates used for exhaust and idle emissions are shown in **Table IV-2**. The emissions factors used were derived from information obtained from the Environmental Protection Agency Study (EPA), AP-42. This study reports data on pollutants based on controlled tests on a variety of stationary and mobile source of pollution.

It should be noted that the Air Quality Analysis Tools (AQAT-3) by the California Air Resources Board and the BAAQMD Handbook were not used to estimate truck emissions because the factors in these studies generalize the emissions for a standard vehicle fleet. They would not accurately reflect specific truck-related emissions.

TRAIN EMISSIONS

EPA AP-42 factors for locomotives provide nationwide factors which would be too broad for use on train-related emissions for this analysis. Therefore, the Locomotive Emission Study was used to estimate train-related emissions.

The Locomotive Emission Study gathers information on rail activity in the State and the associated pollutant emissions. An analysis of control strategies is also provided in efforts to reduce train-related emissions. The study contains estimates of locomotive emissions by air basin, train type, by railroad company, railroad segment, and by engine type. The conclusions of the study include average pollutant emission factors which may be used to estimate train trip-related emissions. The pollutant emissions from rail activity under the project alternatives are estimated based on the following assumptions:

Table IV-2
Exhaust and Idle Emission Rates
Tunnel Air Quality Impact Analysis

Pollutant	**Exhaust Emission Rates at 20 mph**		**Speed Correction**	**Exhaust Emission Rates at 25 mph**		**Idle Emission Rates**	
Hydrocarbons (HC)	2.39	g/mile (1)	0.8386	2.004	g/mile	0.27	g/minute (2)
Carbon Monoxide (CO)	7.93	g/mile	0.7900	6.265	g/mile	0.67	g/minute
Nitrogen Oxides (NO_x)	10.98	g/mile	0.9228	10.132	g/mile	0.22	g/minute
Particulates (PM_{10})	0.20	g/mile	-----	0.200	g/mile	-----	-----

(1) grams per mile.
(2) grams per minute.

Source: David Evans and Associates, Inc., 1993.

1) Time in notch for local trains was assumed to be the following:

Notch	Minutes
8	1.62
7	1.17
6	0.46
5	0.75
4	1.96
3	2.21
2	2.21
1	1.96
Idle	0
Break	0.17

2) Switch train trip is 3.125 miles long.

3) Switch train trips are made by local trains.

4) Seven-car train has 1,700 trailing tons; 3-car train has 800 trailing tons; deadhead move train has 100 trailing tons, and 24-car train has 6,000 trailing tons.

5) Southern Pacific Railroad (SPRR) track from Port of San Francisco would be used by intermodal trains under Alternative 2A.

6) SPRR track would be used from Port of Oakland to areas inland and Santa Fe Railroad track would be used from Port of Richmond to areas inland.

7) It is assumed that emissions from an intermodal train under Alternative 2A will be comparable to emissions from an intermodal train under Alternative 2B for the following reasons: 1) the destinations of intermodal trains will vary from day to day; 2) intermodal trains currently do not run from the Port of San Francisco; and 3) no data on throttle settings for intermodal trains to and from the Port of San Francisco is available. Thus, estimates were not refined to account for these trips.

COMPARISON OF ALTERNATIVES

Estimates of pollutant emissions under Alternatives 2A and 2B are presented, respectively, in **Table IV-3 and Table IV-4**. The difference in the amount of pollutant emissions under the two alternatives is due to the change in transport mode between truck and train trips. With the tunnel project, the increased use of trains under Alternative 2A is mainly insert comprised of switch train trips. This decreases the emissions that would otherwise be generated by truck trips under Alternative 2B. Because the switch trains run for only 3.125 miles, the total emissions under Alternative 2A are generally less than those under Alternative 2B.

REGIONAL AIR QUALITY IMPLICATIONS

Emissions Reductions

With the tunnel project (Alternative 2A), there would be an overall daily decrease in pollutants by 41.21 kilograms of nitrogen oxides, 12.63 kilograms of hydrocarbons, 37.52 kilograms of carbon monoxide, and 0.77 kilograms of particulates (refer to **Table IV-5**). Both the truck and the switch locomotives generate high levels of nitrogen oxides which are typically associated with diesel engines. With the tunnel project, over 340 daily (88,400 annual) truck trips would be replaced with the operation of the switch trains in the yard. Overall, this will lead to a net benefit in regional emissions, and improved air quality in the basin.

Congestion Management

Indirect regional air quality benefits would also be derived from reduced freeway congestion. In particular, the congestion on the Bay Bridge and on Interstates 80 and 880 would be affected, as these would be the major freeway truck routes to the Ports of Richmond and Oakland from the Port of San Francisco.

Both I-80 and I-880 have been identified as major interregional truck routes *(Regional Transportation Plan for the San Francisco Bay Area, September 1991, MTC)*. The junction of I-80 with I-880 has the second highest truck annual average daily traffic (TAADT) of all major truck routes within the region, with an estimated TAADT of 17,412. Of the estimated 1990 truck volumes on I-80 (north of the Bay Bridge approach), approximately 25 percent of total daily truck traffic is related to marine terminal activity *(San Francisco Bay Area Seaport Plan, Final Technical Report, MTC and BCDC)*. An estimated 75 to 80 percent of all truck movements from the Port of San Francisco are to the north, across the Bay Bridge to railroads in Richmond and Oakland.

Table IV-3
Alternative 2A Emissions (Kg/day)
Tunnel Air Quality Impact Analysis

		Pollutant				
Trip Type		**CO**	**SO_2**	**NO_x**	**TOG/ Hydrocarbons**	**Particulates/ PM_{10}**
3	7-car switch trains	1.08	0.84	10.85	0.29	0.21
1	3-car switch train	0.16	0.13	1.65	0.04	0.03
1	deadhead move	0.02	0.02	0.21	0.01	0.01
1	24-car intermodal train	------	------	------	------	------
412	truck trips (local)	85.72	negl.	127.95	28.11	2.47
630	truck trips (non-local)	249.48	negl.	387.15	80.88	7.56
Total		**336.46**	**0.99**	**527.81**	**109.33**	**10.28**

Source: David Evans and Associates, Inc., Vickerman-Zachary-Miller, 1993.

Table IV-4
Alternative 2B Emissions (Kg/day)
Tunnel Air Quality Impact Analysis

		Pollutant				
Trip Type		**CO**	**SO_2**	**NO_x**	**TOG/ Hydrocarbons**	**Particulates/ PM_{10}**
1	24-car intermodal train	------	------	------	------	------
340	truck trips (Inter-Port)	38.78	negl.	53.92	12.97	1.02
412	truck trips (local)	85.72	negl.	127.95	28.11	2.47
630	truck trips (non-local)	249.48	negl.	387.15	80.88	7.56
Total		**373.98**	**negl.**	**569.02**	**121.96**	**11.05**

Source: David Evans and Associates, Inc., Vickerman-Zachary-Miller, 1993.

Table IV-5
Estimated Total Air Quality Emissions
Tunnel Air Quality Impact Analysis

Pollutant	Kilograms Per Day Alternative 2A	 Alternative 2B	 Difference
Sulpher Dioxide (SO_2)	0.99	negligible	0.99
Nitrogen Oxides (NO_x)	527.81	569.02	41.21
Hydrocarbons (HC)	109.33	121.96	12.63
Carbon Monoxide (CO)	336.46	373.98	37.52
Particulates (PM_{10})	10.28	11.05	0.77

Source: David Evans and Associates, Inc., 1993.

With the tunnel project, there would be 340 fewer daily truck trips distributed on the Bay Bridge, I-80, and I-880, which would further reduce traffic congestion on these routes. In addition, the intersection of 3rd and Army Streets, which operates at Level of Service "F" (conditions at capacity, with extremely long delays), would also experience 340 fewer daily local truck trips *(City and County of San Francisco, Congestion Management Program, October 1991)*. As such, the actual air quality and congestion management benefit to the region may be greater under Alternative 2A than shown in **Table IV-5**. Since these truck trips would not be added to the local transportation network and the regional transportation system, there would be a further decrease in emissions associated with the operation of trucks during congested conditions. These include reductions in carbon monoxide and nitrogen oxide from truck exhaust, idling and start-stop operations.

OTHER RELATED FACTORS

In addition to air quality considerations, each alternative scenario would also affect fuel and energy efficiency. Intermodal facilities primarily handle double-stacked container cars, stacked in a two-high, five-unit long configuration. In comparison to conventional equipment, a double-stacked cargo configuration saves fuel, utilizes capacity more efficiently, and requires less maintenance with more efficient handling of cargo.

For example, double-stacked cars are 268 feet long versus the standard 445 feet for the equivalent five piggy back cars required to handle the same amount of cargo. In addition, double-stacked cars have a tare weight of 19,800 per container as compared to 34,200 tare weight per equivalent container on conventional cars. This reduction in equivalent length and weight results in shorter trains which use less fuel. The double-stacked design also has decreased space between individual cargo beds, thereby reducing aerodynamic drag and improving fuel economy.

With the tunnel project (Alternative 2A), an estimated 25 percent of cargo would be transported by rail as compared to 5 percent under Alternative 2B. The increased use of rail under Alternative 2A would result in greater car capacity with improved energy and fuel efficiency.

APPENDIX:

Air Quality Technical Appendix

Segment: SPRR
Train Type: Local 1 deadhead move Table:

Time in Notch/Train

Time	#8	#7	#6	#5	#4	#3	#2	#1
Mins.	1.625	1.16666667	0.45833333	0.75	1.95833333	2.20833333	2.20833333	1.95833333
Hours	0.0271	0.0194	0.0076	0.0125	0.0326	0.0368	0.0368	0.0326
Time	Idle	Break						
Mins.	0	0.16666667						
Hours	0.0000	0.0028						

Emissions Factors in Grams per Hour (Appendix B)

Notch	HP	PART	NOX	CO	HC	SO2
8	2995	743	37004	5003	1023	2966
7	2467	572	30410	3910	772	2434
6	1858	492	24797	2380	540	1848
5	1425	318	19571	1255	404	1441
4	1013	240	14126	755	305	1047
3	685	210	9341	443	238	730
2	363	115	5209	328	180	408
1	109	28	2582	257	140	166
Idle	17	42	1395	454	165	94
Break	105	103	3708	816	372	330

Emissions (In Grams/locomotive)

Notch	PART	NOX	CO	HC	SO2
8	20	1002	135	28	80
7	11	591	76	15	47
6	4	189	18	4	14
5	4	245	16	5	18
4	8	461	25	10	34
3	8	344	16	9	27
2	4	192	12	7	15
1	1	84	8	5	5
Idle	0	0	0	0	0
Break	0	10	2	1	1
	60	3119	309	83	242

Emissions (In Pounds/locomotive)

Notch	PART	NOX	CO	HC	SO2
8	0.0	2.2	0.3	0.1	0.2
7	0.0	1.3	0.2	0.0	0.1
6	0.0	0.4	0.0	0.0	0.0
5	0.0	0.5	0.0	0.0	0.0
4	0.0	1.0	0.1	0.0	0.1
3	0.0	0.8	0.0	0.0	0.1
2	0.0	0.4	0.0	0.0	0.0
1	0.0	0.2	0.0	0.0	0.0
Idle	0.0	0.0	0.0	0.0	0.0
Break	0.0	0.0	0.0	0.0	0.0
lbs.	0.1	6.9	0.7	0.2	0.5

Total no. of locomotives: 0.07

	PART	NOX	CO	HC	SO2
grams	4.0	205.9	20.4	5.5	16.0

Segment: SPRR
Train Type: Local 1 3-car swith trains Table: 1

Time in Notch/Train

Time	#8	#7	#6	#5	#4	#3	#2	#1
Mins.	1.625	1.16666667	0.45833333	0.75	1.95833333	2.20833333	2.20833333	1.95833333
Hours	0.0271	0.0194	0.0076	0.0125	0.0326	0.0368	0.0368	0.0326

Time	Idle	Break
Mins.	0	0.16666667
Hours	0.0000	0.0028

Emissions Factors in Grams per Hour (Appendix B)

Notch	HP	PART	NOX	CO	HC	SO2
8	2995	743	37004	5003	1023	2966
7	2467	572	30410	3910	772	2434
6	1858	492	24797	2380	540	1848
5	1425	318	19571	1255	404	1441
4	1013	240	14126	755	305	1047
3	685	210	9341	443	238	730
2	363	115	5209	328	180	408
1	109	28	2582	257	140	166
Idle	17	42	1395	454	165	94
Break	105	103	3708	816	372	330

Emissions (In Grams/locomotive)

Notch	PART	NOX	CO	HC	SO2
8	20	1002	135	28	80
7	11	591	76	15	47
6	4	189	18	4	14
5	4	245	16	5	18
4	8	461	25	10	34
3	8	344	16	9	27
2	4	192	12	7	15
1	1	84	8	5	5
Idle	0	0	0	0	0
Break	0	10	2	1	1
	60	3119	309	83	242

Emissions (In Pounds/locomotive)

Notch	PART	NOX	CO	HC	SO2
8	0.0	2.2	0.3	0.1	0.2
7	0.0	1.3	0.2	0.0	0.1
6	0.0	0.4	0.0	0.0	0.0
5	0.0	0.5	0.0	0.0	0.0
4	0.0	1.0	0.1	0.0	0.1
3	0.0	0.8	0.0	0.0	0.1
2	0.0	0.4	0.0	0.0	0.0
1	0.0	0.2	0.0	0.0	0.0
Idle	0.0	0.0	0.0	0.0	0.0
Break	0.0	0.0	0.0	0.0	0.0
lbs.	0.1	6.9	0.7	0.2	0.5

Total no. of locomotives: 0.53

	PART	NOX	CO	HC	SO2
grams	31.7	1647.2	163.2	43.8	127.9

Segment: SPRR

Train Type: Local 3 7--car swith trains Table: 1

Time in Notch/Train

Time	#8	#7	#6	#5	#4	#3	#2	#1
Mins.	1.625	1.16666667	0.45833333	0.75	1.95833333	2.20833333	2.20833333	1.95833333
Hours	0.0271	0.0194	0.0076	0.0125	0.0326	0.0368	0.0368	0.0326

Time	Idle	Break
Mins.	0	0.16666667
Hours	0.0000	0.0028

Emissions Factors in Grams per Hour (Appendix B)

Notch	HP	PART	NOX	CO	HC	SO2
8	2995	743	37004	5003	1023	2966
7	2467	572	30410	3910	772	2434
6	1858	492	24797	2380	540	1848
5	1425	318	19571	1255	404	1441
4	1013	240	14126	755	305	1047
3	685	210	9341	443	238	730
2	363	115	5209	328	180	408
1	109	28	2582	257	140	166
Idle	17	42	1395	454	165	94
Break	105	103	3708	816	372	330

Emissions (In Grams/locomotive)

Notch	PART	NOX	CO	HC	SO2
8	20	1002	135	28	80
7	11	591	76	15	47
6	4	189	18	4	14
5	4	245	16	5	18
4	8	461	25	10	34
3	8	344	16	9	27
2	4	192	12	7	15
1	1	84	8	5	5
Idle	0	0	0	0	0
Break	0	10	2	1	1
	60	3119	309	83	242

Emissions (In Pounds/locomotive)

Notch	PART	NOX	CO	HC	SO2
8	0.0	2.2	0.3	0.1	0.2
7	0.0	1.3	0.2	0.0	0.1
6	0.0	0.4	0.0	0.0	0.0
5	0.0	0.5	0.0	0.0	0.0
4	0.0	1.0	0.1	0.0	0.1
3	0.0	0.8	0.0	0.0	0.1
2	0.0	0.4	0.0	0.0	0.0
1	0.0	0.2	0.0	0.0	0.0
Idle	0.0	0.0	0.0	0.0	0.0
Break	0.0	0.0	0.0	0.0	0.0
lbs.	0.1	6.9	0.7	0.2	0.5

Total no. of locomotives: 3.48

	PART	NOX	CO	HC	SO2
grams	208.7	10853.1	1075.6	288.3	842.8